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SCIENCE AND THE PRESS

REFERENCE has been made in these columns, in connexion with the recent report of the Royal Commission on the Press, to the failure of the British Press to report adequately on topics of great importance, a failure for which the Government is in part to blame by the severe rationing of newsprint (see *Nature*, August 13, p. 247). At the same time it was pointed out that the inadequate coverage of news may be the first steps towards actual suppression of the truth by some authority—private, public or otherwise—, and that if civil liberties are being endangered, the Press must have the available space, and must use it, to direct attention to the threat in question.

The admirable presidential address which Sir David Rivett delivered to the Society of Chemical Industry at its annual meeting in Manchester on July 12 provides a pertinent example of these very points. That address was scarcely noticed in any daily paper, although both the first part, with its examples of lines of work which concern the British people as members of one Commonwealth, and the second, in which he touched upon a specific danger to freedom of investigation and communication, deserve the attention of a far wider audience than that which was assembled in Manchester. Moreover, in the second part of his address Sir David dealt with matters which bear on the freedom of the Press quite as much as the Royal Commission's report, and show how vital it is that there should be the freest and widest possible channels for public discussion.

From his survey of problems of population and food, Sir David passed on to a consideration of the recent changes in the status of the body in Australia which has borne so much responsibility for such investigations—the Council for Scientific and Industrial Research, recently modified and renamed the Commonwealth Scientific and Industrial Research Organisation. An outstanding characteristic of this Council of some twenty men of science was that it had full freedom to pursue its investigations in accordance with its own estimate of the scientific needs of the country and the scientific ability that was available to cope with them. Unlike its counterpart in New Zealand, it was not built on the normal departmental pattern, and the Council's freedom to initiate work and recruit its own staff with consequent freedom from direct control have, in Sir David's opinion, given it some advantage over the Department of Scientific and Industrial Research in New Zealand.

The changes in organisation and status which Sir David Rivett regards with some concern are the direct result of the tendency to regard science itself in most of its branches as a potential engine of war, with the consequent feeling that all scientific work even if it appears only remotely associated with war technology, must be closely guarded, controlled, in greater or less measure kept out of view, and even its directions of development kept under supervision. On this question of secrecy and security Sir David is forthright. The tendency may explain certain changes, but it does not justify them. He takes his

stand with D. E. Lilienthal, Sir Henry Dale and Sir Robert Robinson in holding that a high price has to be paid for secrecy in the technical field, and that security is best attained not through secrecy but through achievement.

Sir David recognizes that an encouraging feature of recent discussions on control and development of scientific work, prompted more particularly by the new context in which the work of those divisions of the Scientific and Industrial Research Organisation bearing on, or likely to have a bearing on, defence developments, has been the keen desire all round to see every factor clearly. Members of the Council realized that any line of work associated with war technology would sooner or later be required to come under far more intimate departmental control, scrutiny of personnel and programme, and publication of results than would ever be sought in their other and more extensive activities. As early as 1947 the Council urged that work related to defence technology should not be in its hands, and an immediate result of Government acceptance of this view was the placing of the Division of Aeronautics under the Department of Supply.

When, however, this change was legalized by the passage through the Australian Parliament of a short Bill authorizing the transfer of any work or class of work specified, to any selected department, by mere proclamation, the limitation of such transfers to work associated with defence only was dropped, and at the moment any or all of the work of the Organisation can legally be placed under departmental control by proclamation. Ministerial declarations that there is no immediate intention to transfer any other Divisions than that of Aeronautics have not entirely dispelled Sir David's anxiety about the future.

Nor is this all. When the original legislation of 1926 was repealed in March of this year and a new Commonwealth Scientific and Industrial Research Organisation created, the Council became entirely advisory, its powers and functions being transferred to an executive of five, three being full-time members with scientific training and appointed for seven years (see *Nature*, April 30, p. 671). There is a new penalty clause for any member of executive or staff, advisory council or State committees who, except in the course of his duty or with the approval of the executive, discloses any information concerning the work of the Organisation or the contents of any document in its possession. Oral assurance from the Minister that such legal clauses will not be permitted to operate to the detriment of the work of the Organisation have obviously left Sir David uneasy.

As he rightly observes, this is not entirely a local matter for Australia. The situation varies in its intensity in different countries; but Sir David should be assured of a warm response from men of science in Great Britain to his suggestion that they may be able to help one another in finding the best practical solution. That admittedly may have to be a compromise, but even for an acceptable compromise, the help of men of broad outlook, capable of seeing every side of the problem as it exists to-day, will be required, and the wider their experience and the greater their independence of particular political situations the better. Sir David says rightly that from the scientific side we owe it to the politician and statesman to do our best to assist in solving a problem for the setting of which we must accept some responsibility. Men of science will have only themselves to blame if they fail to prove that the political responsibilities can be discharged by methods which will not, in the view and on the experience of men of science, handicap the progress of science and its application.

Assessment of the risk associated with specific actions, whether to restrain or to restore freedom, to increase or to reduce secrecy precautions does require a very high order of judgment. To arrive at the right measures demands public debate such as can only be carried on in a Press that is truly free. The very fact that Sir David's address has passed unnoticed shows how inadequate is the British Press to-day for discussion of issues of first-class importance. Furthermore, it is upon the existence of a Press that is really free that we must rely ultimately for the most effective safeguards against the dangers to scientific work which Sir David fears in Australia, and which are inherent in the Atomic Energy Act in Great Britain, to mention only one example. Safeguards are equally necessary against the abuse of individual liberty, and they become the more important when necessity is laid upon us of discriminating between those whose primary loyalty is neither to a scientific discipline or professional tradition nor to the society of which they are members, but to organisations or people who may be potential enemies of all three.

These passages of Sir David's address endorse most emphatically all that is said in the report of the Royal Commission on the imperative necessity of making available for the daily and the scientific and technical Press of Great Britain adequate supplies of newsprint, so that in the future there can be no excuse for failure to report and discuss all questions of public importance, among which this issue of secrecy and freedom of scientific investigation and publication takes a high place.

THE COMPOSITION OF THE EARTH

An Introduction to the Theory of Seismology

By Prof. K. E. Bullen. Pp. xiv+276. (Cambridge: At the University Press, 1947.) 18*s*. net.

IN view of the number of different lines of approach, a borderline subject is apt to amass a vast literature, some of it difficult of access to investigators. This is particularly true of seismology; the phenomena of earthquakes have attracted the attention of many famous geologists, and the recording of earthquake tremors involves the methods of experimental physics, while the interpretation of the records of earthquakes has provided a great stimulus to the development of the theory of the propagation of disturbances in elastic media and has ultimately thrown considerable light on the composition of the interior of the earth. Many books have been written on seismology in its various aspects, but many of the

most interesting modern geophysical developments have hitherto been available only in the original papers. It is therefore of considerable interest to read the elegant exposition that Prof. K. E. Bullen has presented in the book under review.

To obtain numerical results concerning the distribution of density and elastic properties within the earth demands a quantitative treatment, and to attempt to describe modern researches without at least an outline of the mathematical arguments involved would be quite unsatisfying. In this respect Prof. Bullen's exposition is ideal, for at no stage does he obtrude mathematics for mathematics' sake, but treats it strictly as his servant. Much of our detailed knowledge of the density distribution is directly the result of his own recent researches, yet he keeps a strict sense of proportion throughout; indeed, in an attempt to keep the book down to a convenient size (and, be it added, a reasonable price) he has refrained from giving the necessarily long lists of references, so that a reader unacquainted with this field of study would not suspect how great has been Bullen's own contribution to the subject. In view of the author's extensive pruning away of unnecessary detail, it would scarcely be practicable to summarize the whole treatise. It is surprising how much factual detail has been included with strict relevance, and the general reader who is prepared to skip the mathematics will learn as much as by reading a more diffuse work. Yet the book is strong meat, and is worth detailed study throughout.

In transmitting earthquake pulses from a focus of disturbance to great distances, the earth behaves as an elastic solid. The earlier chapters of this book, like those of other treatises on theoretical seismology, are accordingly concerned with the propagation of waves through the interior and over the surface of an elastic solid; an indication is given of the way in which viscosity and elastic afterworking can be allowed for. It has long been known that below a depth of about 0·452 of its radius the earth undergoes a sudden change in properties, so that the 'Oldham–Gutenberg core' does not transmit distortional waves (at any rate in the outer part of the core), and in this respect behaves as a liquid. The presence of discontinuities at certain depths raises complications in the propagation of elastic waves in a spherically stratified body, and this book includes a summary of Prof. Bullen's own discussion of the forms assumed by the travel-time curve in such circumstances.

As is well known, an analysis of the time of travel of a wave from a shock near the surface to stations at various angular distances will give the velocity at all depths reached by the rays, and such analyses have been carried out, notably by Wiechert, Knott and Gutenberg. If any spherically symmetrical region is supposed of uniform chemical composition but of density modified by the effects of gravitational attraction, the method of Adams and Williamson then enables a calculation to be made of the variation of density with distance from the centre. There is good evidence that the chief discontinuities within the earth are known, including an 'inner core' at a depth of about 5,120 km. Using the most plausible model, in which the interior of the earth consists of seven regions, Bullen has worked out the detailed variation of density with depth; any such distribution has to give the correct moment of inertia of the earth about a diameter. By-products of this investigation are the values of the pressure, the elastic constants and the 'local' value of gravity at all depths. Tables of these values are given in the book, with the essential steps of the theory. Prof. Bullen refers briefly to the effect of the ellipticity of the earth on the times of transmission of compressional and distortional waves through the interior; but one needs to be acquainted with his original papers in order to realize that it was he who carried through the monumental work of calculating and tabulating the ellipticity correction in a form suitable for use in routine reductions of seismogram readings.

Many other topics, such as the theory of the seismograph, the depth of earthquake foci, macroseismic data, microseisms, the construction of travel-time tables and the seismological evidence of the layering of the continents are discussed in this treatise, finishing with a reference to the seismic recording of compressional waves from the Bikini atomic bomb test. But undoubtedly it is the discussion of the nature of the deep interior of the earth that will make the greatest appeal to geologists and geophysicists as well as to the non-specialist.

The book is of convenient size and the typography is excellent; the work is remarkably free from misprints. Its publication should be a valuable stimulus to further seismological investigations.

R. STONELEY

THE PALÆOLITHIC HERITAGE

The Gate of Horn

A Study of the Religious Conceptions of the Stone Age, and their Influence upon European Thought. By Gertrude Rachel Levy. Pp. xxxi+349+32 plates. (London: Faber and Faber, Ltd., 1948.) 42*s*. net.

MISS G. R. LEVY has, in this closely reasoned and well-documented book, attempted to trace the development of man's attitude, in certain ritual aspects, to religious beliefs from palæolithic times in Europe down to the performances of Greek tragedies in Athens. In order to trace the "palæolithic heritage", and to interpret the remains on which all study must depend, the author has turned to primitive peoples whose beliefs and practices have been recorded by modern anthropologists, and examined critically what can be fairly deduced for the explanation of apparent similarities between civilizations far separated in time. This is not one of those books in which material evidence is thrown together pell-mell; what the best authorities have to say is carefully considered.

As 'palæolithic' gave way to 'neolithic' and 'chalcolithic' man, then to the developed urban civilizations of Egypt and western Asia, the course of change and survival in the heritage is discreetly traced, and, surprisingly enough, even central America can be used to establish the course that beliefs which found expression in art, symbolism and ritual took, deviating thus from an original norm of the same kind as may be assumed to underlie those of the earliest Europeans. The study passes on, through Crete and the Mycenean period in Greece, to the mystery cults and the intellectual revolt in Greece.

Comparative studies in religion of this kind are not uncommonly looked at askance. It is true that they demand not merely wide knowledge of very various fields of learning, but also an exactitude in appraisal of each detail, and precision in dialectic, so that few attempts to trace what may lie behind that which

appears to be material remains of a cult nature can be successful. The critics are themselves open to criticism in this matter; inaccuracy in some detail is not sufficient to disprove the general truth of an argument.

In this case, the bases of argument are soundly laid. Proof that the designs and paintings in Stone Age caves and that objects found in such caves are of types known elsewhere to be connected with a religion or religions, expressed in symbols, is amply demonstrated. Where, in the later periods, the written word can assist us to understand the symbolism, the texts are used reasonably, with good and illuminating parallels. Specialists in one or the other fields of learning covered will no doubt find reason to differ in interpretation on isolated points.

What is called "religion", with its correlative "magic", the conceptions the author tries to elucidate, was, for the periods concerned in this study, something much more than our modern words indicate. Someone once said that Shamanism is much more than a religion; it is a way of life. That is true of much that Miss Levy has to say in this most instructive book, which is the product of many years of labour not only in the study but also in actual contact with objects. I have learnt a great deal from it.

SIDNEY SMITH

SMALL BUSINESSES

Small Business

Its Place and Problems. By A. D. H. Kaplan (Committee for Economic Development, Research Study.) Pp. xiv+281. (New York and London: McGraw-Hill Book Co., Inc., 1948.) 19*s*. 6*d*.

FOR the British reader, Mr. A. D. H. Kaplan's study serves two purposes. It affords an interesting descriptive review of the scope and activities of small business ventures in the United States; and it offers an analysis of certain aspects of the running of the smaller enterprises. The main disappointment in Great Britain will be in the fact that the author has not included a review of management practices and methods, nor has he given anything but the smaller emphasis to the problems of the manufacturer as against the trader. British interest, as it happens to-day, is the other way. The author's aim is summarized in the two questions he poses in the opening paragraphs: "What is the role of small business in the economy? How can small business be helped to contribute its full share to post-war employment and prosperity?"

The first astonishing fact that emerges from the American scene pictured here is the size of the 'small business' population. "In the total of 45 million persons gainfully employed as of 1939, business firms outside of agriculture accounted for 28 million; of that business total about two-fifths, or roughly 11 million, gained their livelihood from the 3·3 million firms with 0 to 50 employees." The war years made a certain inroad; but the ravages have been repaired, and an estimate of the current position suggests that the 'small business' category (up to a hundred employees in manufacturing, and up to twenty in trade) accounts for 92 per cent of all establishments, 45 per cent of the persons employed, and 34 per cent of the total value of output or sales.

These are really astonishing figures to the British industrialist, who has come to regard the United States as virtually synonymous with large-scale operation in industry. Admittedly, only 10 per cent of these establishments are engaged in manufacturing, the bulk being in wholesale and retail trade and in transport and other services. But it is an interesting feature of the American scene that something like half a million small establishments should fall or discontinue each year and be replaced by a comparable number—and the bankruptcies, apparently, are seldom more than 4 per cent of the yearly losses.

Perhaps these figures do reflect one of the chief characteristics of the smaller firms—their individuality and independence, which have enabled them to exhibit "this high degree of stamina in a world where big business has made the spectacular gains".

Mr. Kaplan's examination of the reasons that explain this stamina covers a wide field. He starts from such typical features as "identity of management and ownership, an absence of specialised staff for separate functions, . . . a personal relationship between owners and employees and customers, the affiliation of the firm with a local community and chief dependence for its market on a local area (these two factors apply chiefly to the trading enterprises), . . . simplicity of organisation". Because small and big business differ deliberately in their methods and objectives, direct comparisons of their relative efficiency are seldom possible. Moreover, the smaller unit does not usually maintain the records or procedures that permit of detailed study of productivity or costs. What studies have been made reveal that "the differences in efficiency among the small enterprises are more extreme than those between small and large firms", and that "the middle-size firms of an industry commonly make a better average showing on costs and earnings than do either the giants or the smallest members". "The overall tendency is for unit costs to diminish as size increases until the big business category is reached."

In many instances the success of a small firm is due to a shrewd assessment of a particular market; in others the enterprise is kept alive simply because the owner has other income from more lucrative sidelines, to which the business is an interesting supplement and a source of prestige. "The inevitable conclusion emerges, however, that the calibre of the management has, on the whole, been the most decisive factor influencing the success or failure of the small firm. . . . Many firms have failed without realising that the chief source of their trouble was not lack of capital or external economic forces, but rather the cumulative effect of substandard performance and cost leaks that they were unable to detect."

These conclusions are supported by a thoroughgoing review of a variety of factors in the working of a competitive trading system—sales methods, pricing, resale price maintenance, marketing, and so on—as well as of the influence of labour relations and Government regulations or assisting agencies. They lead on to an interesting chapter on "Education and Public Policy" which shows how official and private institutions can contribute to an advancement of the professional competence of the small-firm owner. The author sees the owner-manager as the symbol of free enterprise, as the guardian of basic economic liberties, as contributing to the industrial organisation of the country an important element of flexibility, an outlet for versatility. The key to continuing existence lies in steady succession, and he makes the

suggestion that a more open recognition of this by the owners might often enable a promising younger employee to remain with the small firm instead of seeking other pastures in the larger units.

An interesting, instructive and thought-provoking study is this work, for which Mr. Kaplan deserves commendation. A final word needs to be said for its sponsors, the Committee for Economic Development, through its special sub-committee on the problems of the small business. The very existence of this body may be a useful hint to British industry—the more so when we read that the United States Department of Commerce, in co-operation with the Bureau of Standards, has recently established a Small Business Division, specifically for advice and the promotion of management competence. E. F. L. BRECH

MUSEUMS AND THEIR PURPOSE

The Museum

Its History and its Tasks in Education. By Dr. Alma S. Wittlin. (International Library of Sociology and Social Reconstruction.) Pp. xv+297+24 plates. (London: Routledge and Kegan Paul, Ltd., 1949.) 25*s.* net.

IN a world of changing values and perspective, professional museum folk are not alone in endeavouring to adapt their outlook and methods to the new conditions now prevalent. They are aware that they have a distinct niche in any community; but they are not so sure of their distinctive message to that community. In these circumstances, many will readily turn to a book with the alluring title of "The Museum" and a sub-title "Its History and its Tasks in Education". Broadly speaking, it is felt that they will be disappointed, for the book does not contain the ready answer to museum problems. On the other hand, many will be intrigued by some statements of the author and given much food for thought and practical experiment by some of her other remarks.

At the outset, those in the museum profession will feel defiant when the author accuses directors of a lack of a well-defined purpose or policy; she assumes that they live in a drifting world, being carried willy-nilly by the force of circumstances. Admittedly, it is at times a temptation for directors and curators to have their policy dictated by the impact of incoming collections, but surely the day is long since past when such fortuitous circumstances held sway. Speaking generally, it can be categorically stated that the majority of our controlling committees and directors possess vision but lack finance. We would suggest that if Dr. Alma S. Wittlin had had the opportunity of revising her manuscript when going to press—it was written in 1945—she would have modified many of her views and incorporated much of what has been written in the *Museums Journal* and elsewhere, and discussed in Association conferences and Federation meetings throughout Great Britain.

The history of the museum in Europe is dealt with in outline, though with a wealth of references that makes this part of the book an important source of information. Museum collections are generally described from the historical or geographical point of view. Dr. Wittlin has adopted a more philosophical approach and has endeavoured to relate them to the lives and imaginations of the men and women who assembled and treasured them. In this aim she has been eminently satisfactory.

Following the historical part, the author discusses the two main efforts made for the reform of museums. One of these commenced in the middle of the nineteenth century and came to an abrupt close in 1914; the second developed in the period between the two World Wars. With regard to the first period, Dr. Wittlin considers that hoarding was the predominant policy of museums and that it overshadowed, and indeed stultified, any attempts at the broader ideas of education. During the second period, she is of the opinion that overcrowding of exhibition material still dominated the scene, and that museums, even between 1920 and 1939, were not developing as true assets of society.

Even the most ardent supporter of museums will admit that as tools in modern education they are still in their early stages of development. But as centres of combined recreation and education they have definitely taken their place in the life of the community. Their objective value is abundantly recognized.

Although probably not agreeing with many of the conclusions reached by Dr. Wittlin in this provocative book, museum folk and others interested will be grateful to the author for her energetic researches and philosophical approach to a baffling problem. F. S. WALLIS

APPLIED NUCLEAR PHYSICS

Atomic Energy Year Book

Edited by Dr. John Tutin. Pp. xx+237. (London: Temple Press, Ltd., 1949.) 21*s.* net.

THE preface to this publication states that it is intended to assist the integration of industry and science in the development of atomic energy and its associated fields by providing up-to-date information.

The almost inevitable summary of the development of nuclear physics—probably the most difficult part of the book to write—occupies the first chapter, and succeeds reasonably well in view of its limited space of twelve pages of text, apart from a mere half-dozen or so badly expressed or insufficiently explained points.

Chapters 2 and 3 deal with the construction and operation of piles in general. The latter chapter, the longest in the book, contains much useful information, but unfortunately it is badly arranged and presented. One gets the impression that it was written by two or even three authors who failed to co-operate sufficiently in deciding the field to be covered by each. Thus the phenomenon and consequences of delayed neutrons are dealt with twice; so also are the question of the choice of moderator materials, and the source of the neutrons which start a pile operating.

The remaining chapters deal with the broader aspects of atomic energy, and are less technical; the presentation on the whole becomes now much better. The section on "By-products of Atomic Energy" is a well-written and interesting account of tracer and allied work in many fields.

Two separate chapters are devoted to medical work; one takes the form of a number of progress

reports from various medical centres. One wonders, however, why the reports are entirely from American institutions; could not one single British medical school, for example, be persuaded to contribute? On the other hand, the "Survey of Atomic Energy Developments" is well balanced and contains some information not readily available, especially regarding the work in progress in Great Britain. The section on the American effort, however, contains much administrative and organisational detail of little interest to most readers.

For those interested in the political and economic repercussions of atomic energy, there are short chapters on international control, and the financial and legal aspects. In view of the great importance of the former, one feels that insufficient space is devoted to it; in particular, an unbiased summary of the respective views of the Eastern and Western blocs on the subject would have emphasized the importance of this section of the book.

Two very useful chapters, one dealing adequately with safety precautions, and the other giving full details of the radioactive isotopes available in Britain and America, will be of special interest to those contemplating tracer and allied work; so also will the useful bibliography of books, references and journals.

One feels, in fact, that the book will more than fulfil its aim so far as those with some previous knowledge of the subject are concerned, for they will find in it much useful reference material.

D. F. BRACHER

VECTOR AND TENSOR ANALYSIS

Vector and Tensor Analysis

By Prof. Louis Brand. Pp. xvi+439. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 33*s*. net.

THE vector analysis of Gibbs and Heaviside and the more general tensor analysis of Ricci are now recognized as standard tools in mechanics, hydrodynamics and electrodynamics. Their use not only materially simplifies and condenses the exposition, but also makes mathematical concepts more tangible and easy to grasp. Moreover, tensor analysis provides a simple automatic method for constructing invariants. Since a tensor equation has precisely the same form in all co-ordinate systems, the desirability of stating physical laws or geometrical properties in tensor form is manifest. The perfect adaptability of the tensor calculus to the theory of relativity was responsible for its original renown. It has since won a firm place in mathematical physics and engineering technology. Thus Sir Edmund Whittaker rates the tensor calculus as one of the three principal mathematical advances in the last quarter of the nineteenth century.

That this was not always the accepted view is evidenced by the following quotation from the preface to the third edition of Tait's "Quaternions": "Even Prof. Willard Gibbs must be ranked as one of the retarders of quaternion progress, in virtue of his pamphlet on *Vector Analysis*, a sort of hermaphrodite monster, compounded of the notations of Hamilton and Grassman". This robust outburst evoked a convincing refutation from Gibbs which was published in *Nature* (**43**, 511; 1891). That Gibbs has entire justification is evident, to cite a few instances, from a perusal of the "Vectorial Mechanics" of Brand (1930) and more recently of E. A. Milne (1947), and from a more general point of view E. H. Neville's "Multilinear Functions of Direction" (1921) and the extension of vectorial ideas to function space associated with the recent work of Synge, Prager and McConnell.

The present work not only comprises the standard vector analysis of Gibbs, including dyadics or tensors of the second rank, but also supplies an introduction to the algebra of *motors* which is apparently destined to play an important part in mechanics as well as in line geometry. As the notion of motor is not very widely disseminated it may be well to explain that if ε is a unit with the property $\varepsilon^2 = 0$, a *unit line vector* with Plücker co-ordinates $\mathbf{a}$, $\mathbf{a}_0$, $|\mathbf{a}| = 1$ is written as a *dual vector*

$$\mathbf{A} = \mathbf{a} + \varepsilon\mathbf{a}_0.$$

A motor is then of the form

$$\mathbf{M} = \mathbf{m} + \varepsilon\mathbf{m}_0 = (\lambda + \varepsilon\lambda')\,\mathbf{A},$$

where λ and λ' are scalars. The idea of a unit ε such that $\varepsilon^2 = 0$ is originally due to Levi-Cività, who devised it in connexion with Sobrero's hypercomplex numbers $z = x + jy$, where $1 + 2j^2 + j^4 = 0$. In this notation $1 + j^2 = \varepsilon$.

In this book tensor analysis is first developed in three-dimensional space and then extended to n-dimensional space. As in the case of vectors and dyadics, the invariant tensor is distinguished from its components. This leads to a straightforward treatment of the affine connexion and of covariant differentiation, and also to a simple introduction of the curvature tensor. It is, indeed, a praiseworthy characteristic of the author's treatment that the intrinsic properties of the entities are emphasized, while the background of co-ordinates is relegated to its proper subordinate position.

The contents are as follows: vector algebra, motor algebra, vector functions of one variable, linear vector functions, differential invariants, integral transformations, hydrodynamics, geometry on a surface, tensor analysis, quaternions. In addition, there are numerous exercises at the end of each chapter.

The rich and diverse field amenable to vector and tensor methods is one of the most fascinating in applied mathematics. The author hopes that the reasoning will not only appeal to the mind but also impinge on the reader's aesthetic sense. For mathematics, which Gauss esteemed as the queen of the sciences, is also one of the great arts. Here he quotes the words of Bertrand Russell. "The true spirit of delight, the exaltation, the sense of being more than man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as in poetry. What is best in mathematics deserves not merely to be learned as a task, but also to be assimilated as a part of daily thought, and brought again and again before the mind with ever-renewed encouragement. Real life is, to most men, a long second-best, a perpetual compromise between the real and the possible; but the world of pure reason knows no compromise, no practical limitations, no barrier to the creative activity embodying in splendid edifices the passionate aspiration after the perfect from which all great work springs."

L. M. MILNE-THOMSON

The Annual of the British School at Athens

No. 43, 1948. Pp. viii+280+59 plates. (London: British School at Athens, 1948.) 63*s*. net.

THE mastery of detail which now distinguishes classical archæology is well exemplified in this admirable volume. Half of it is taken up by an exhaustive investigation of unprepossessing objects excavated during 1931–32 in a sanctuary on Ithaca, dating from the ninth to the sixth centuries B.C. Much of the pottery is Corinthian mass-produced ware, painted with a limited repertoire of traditional patterns, animals and occasionally human figures, while other Greek and even Etruscan imports in various materials appear from time to time in smaller numbers.

But the largest element among the finds consists of local pottery imitating the Corinthian, and to a lesser extent the other Greek wares, in both shapes and decoration. Martin Robertson is able to trace the influence of the imports and the entire development of the local craft in astonishing detail, giving us an insight into the minds of these very provincial artisans. This method of research could be applied outside the classical field where there is a comparable abundance of remains of one class, for example, the bronze vessels of primitive China or the pottery of the Peruvian coast; and it should then be possible to follow the labours of generations and estimate the duration of each stage of culture.

Many points of interest emerge from O. A. W. Dilke's comparative study of the auditorium in Greek theatres, and T. W. French's summary of the post-war condition of the monuments in the Dodecanese is the nearest equivalent in English to a guide to those exceptionally historic islands; the remaining articles will concern specialists alone.

Turf

A Book about Golf Greens, Tennis Courts, Bowling Greens and Playing-Pitches, no less than Lawns; their Making and Keeping according to Modern Practice. By I. G. Lewis. Pp. 141+11 plates. (London: Faber and Faber, Ltd., 1948.) 12*s*. 6*d*. net.

AN attempt is here made to condense modern British greenkeeping practice, including the treatment of bowling greens, football fields, cricket grounds, tennis courts and golf courses, into a comparatively slim volume. Much of the work is sound; but the text suffers from the liberal use of the superlative and from regrettably frequent inaccuracies and dogmatic statements which would not pass unquestioned by either greenkeeper or research worker. Despite the limited space, there is also much repetition.

Grasses considered valuable for turf are described; but limitations of space doubtless prevented comprehensive treatment. Pedigree Aberystwyth strains are stressed, and while acknowledgment is made to the indirect contribution to greenkeeping of the Welsh Plant Breeding Station, there is no mention of the direct investigations of the St. Ives Research Station, though the author has obviously drawn from its published work.

The establishment of turf from seed is dealt with in some detail, while considerable space is rightly devoted to the renovation and maintenance of existing turf. There is, however, a marked tendency to vagueness at points at which explicit instructions would be most helpful, as illustrated, for example, by the bald statement "elimination of worms is best accomplished by using wormkiller—and there are many reputable brands—once or twice a year".

Although published in 1948, this work has evidently been in preparation for some time, since some sections, notably that dealing with weedkillers, have already been rendered out of date by research work carried out in 1947 and 1948. Quoting only one example, loosely termed "hormones", based on 2-methyl-4-chlorophenoxyacetic acid, while 2 : 4-dichlorophenoxyacetic acid formulations, widely used in the United States, are dismissed as only just beginning to receive attention in Britain.

The work concludes with a prophetic chapter on future trends, much of which is already accepted practice, development being limited only by present difficulties of commerce.

Urban Geography

A Study of Site, Evolution, Pattern and Classification in Villages, Towns and Cities. By Prof. Griffith Taylor. Pp. xv+440. (London: Methuen and Co., Ltd., 1949.) 25*s*. net.

THE subject which this work attempts to epitomize has become so important in the curriculum of geography that comprehensive statements and re-statements of its purpose and content are regularly appearing. Partly for reasons of its practical value in planning, it is, however, a subject which makes stern disciplinary demands on those who undertake comprehensive commitments within it, and there is no longer the same welcome, as formerly, for collections of town studies, only popularly treated, such as this book is. The attention paid to the important city of New Orleans will make the reviewer's meaning clear: as it is only one of a miscellany of two hundred town studies—the number should have been heavily reduced—it has only some eight hundred words to itself, in addition to hastily drawn sketches on a completely inadequate geographical scale. The most useful feature of the book is an extensive bibliography, which is marred, however, by the absence of any guide to the greatly varying merits of the works mentioned. W. FITZGERALD

Logbook for Grace

Whaling Brig *Daisy*, 1912–1913. By Robert Cushman Murphy. Pp. xiii+290. (London: Robert Hale, Ltd., 1948.) 15*s*. net.

UNDER this somewhat obscure title is hidden one of the most delightful naturalist log-books ever published. It dates from 1912 when Dr. R. C. Murphy followed his university course with a trip on the New Bedford whaling and sealing brig *Daisy* on a round trip in the South Atlantic to South Georgia and back. The journal was written for his wife and posted to her in instalments when opportunity occurred. The *Daisy* was mainly concerned with the slaughter of sea-elephants at the Bay of Isles, South Georgia, but also captured a few sperm whales. The diary treats chiefly of whales, penguins and albatrosses, but has many human touches and reflexions on whalemen and others. It is a lively book, and at the time of writing must have contained much about the life of the southern ocean and its islands that was fresh and unknown. If modern whaling, as well as several Antarctic expeditions, have made South Georgia and its animal life better known, Dr. Murphy's observations are so lively and exhaustive that their freshness and vivacity are unimpaired.

R. N. R. B.

GOETHE AS NATURAL PHILOSOPHER

By Prof. E. N. da C. ANDRADE, F.R.S.

GOETHE, the greatest poet that Germany has produced, was a dominating intelligence who must claim a prominent place in any history of the human mind, and he devoted a considerable part of his effort to scientific studies. Further, he attached the greatest importance to this part of his achievement: he said to Eckermann—who played to him the part of Boswell to Johnson—"I do not attach importance to my work as a poet, but I do claim to be alone in my time in apprehending the truth about colour". It is not suggested that this represented his balanced judgment—passages can, of course, be quoted to show that he attached the greatest value to his poetry, as when he spoke of it to Eckermann as *Mein Eigentliches Glück* and regretted the time spent on anything else—but, even if an exaggeration, it is one of many instances showing that for him his science was vastly significant. Yet we must face the fact that while there is in this scientific work of his much that is of the greatest interest, for the light that it throws on a superlative and complex character, there is not much—except, some would contend, in his botanical studies—that is important for the history of science. Further, it is, alas, precisely where he thought his scientific work most significant, namely, in his attacks on Newton and in his theory of colour, that he most completely fails. Goethe's scientific work may, perhaps, almost stand with Newton's work on theology and chronology—excellent, in many ways, if judged by the standards of the times, very important in the eyes of its producer, but not likely to have been remembered to-day had it been produced by a lesser man.

A great man makes great mistakes, and to understand how Goethe came to fail we must consider what manner of man he was, what his outlook and attitude were. For him Nature was all one, a manifestation of the Godhead, as Sherrington has so well emphasized. He wrote:

"What God would stand outside without concern
Letting creation on his finger turn!
God must inspire all being from within
Nature with Him, Himself with Nature kin.
So that all fabric which his wisdom weaves
Full of his form, full of his spirit lives."*

Characteristic of Goethe was his rapture in open air and light. He was, above all, a man of his eyes: with his keen sight he even derided spectacles, saying, in his attack on instruments as a means of attaining scientific truth, "I have found in life, in the main and on the whole, that artificial means with which we help our senses do not have a good moral influence on man. He who sees through spectacles thinks himself cleverer than he is, for the equilibrium between his outer senses and his innate capacity for judgment is disturbed.†" This delight in things seen stands out particularly by contrast with his attitude to things heard: music, although it gave him some pleasure, does not seem to have moved him profoundly, and he said himself "gegen das Auge ist das Ohr ein stummer Sinn"—the ear is a blunted sense compared to the eye. The words *schauen*, *Anschauung* dominate his vocabulary. *Anschaulichkeit* was what he demanded of scientific theory.

For a man of this make-up the methods of physics were repugnant. When he thought of colour he thought, in particular, of the colours that burst upon his eye when he made that journey into Italy which was such a turning point in his life. Colour was a glorious aspect offered by Nature, and by art in Italian pictures—blooming trees, far hills, Titian and Caravaggio. He was seeking to find out what colour was, in the spirit of the Middle Ages, rather than how coloured lights behaved, in the spirit of Newton. He did not believe that dragging light into the laboratory and submitting it to what he thought of as wholly artificial conditions could tell us anything as to the colour of Nature or the nature of colour. "No dark room," he cries:

"Friends, avoid the darkened chamber
Where light's pinched and pushed and trimmed,
Where the miserable chapter
Bow before the falsehood limned.
Sham and superstitious preachers
Of false doctrine we despise:
In the heads of these your teachers
Leave the spectres and the lies."*

He derides the complications of Newton's simple experiment: for the spectre (*Gespenst*) to appear, he says, the following is necessary: 1, a glass prism; 2, triangular; 3, small; 4, a shutter; 5, an opening in it; 6, this very small; 7, in image of the sun, coming into the room; 8, from a certain distance; 9, falling on the prism in a certain direction; 10, forming on a board; 11, that is at a certain distance behind the prism. When he found that if he looked at a white wall through a prism he did not see a broad band of colour, as he had expected on his mistaken reading of Newton, but a white surface with coloured fringes at its boundaries, he was convinced that Newton was wrong, and attacked him in unmeasured terms—for example, "I must," says he of Newton, "quote Reynard the Fox and say 'But I well perceive that lies are needed, and in full measure'."

This is no place to discuss the misunderstandings and false reasoning of which the "Zur Farbenlehre"—his great, in volume, treatise on colour—is full: it is, perhaps, worthy of remark that he called it "Contributions to the Theory of Colour" rather than "The Theory of Colour", feeling, no doubt, that he had not exhausted the subject. He thought of colour as essentially involved with the contrast of light and darkness: the dark background so often helpful for the observation of certain effects was for him an

* As the translation, for which I am responsible, of this and other passages here quoted is not absolutely literal, I give, in this case and the others, the original.

Was wär' ein Gott, der nur von aussen stiesse,
Im Kreis das All am Finger laufen liesse!
Ihm ziemt's, die Welt im Innern zu bewegen,
Natur in Sich, Sich in Natur zu hegen,
So dass was in Ihm lebt und webt und ist,
Nie Seine Kraft, nie Seinen Geist vermisst.

† "Wanderjahre", Book 1, Chapter 10.

* Freunde, flieht die dunkle Kammer,
Wo man Euch das Licht verzwickt
Und im kümmerlichsten Jammer
Sich verschrobnen Bildern bückt.
Abergläubische Verehrer,
Gab's die Jahre her genug,
In den Köpfen Eurer Lehrer
Lasst Gespenst und Wahn und Trug.

essential. Once more, he summarized his general conclusions elsewhere in poetry:

"If you fitly can unite
Bright and blackness, shade and light,
Colour's secrets you may claim.
Splitting light unique and holy
Hold we for egregious folly,
Not to use a harsher name."*

His complete misunderstanding of the significance of Newton's work, his senseless attacks on Newton's integrity and authority, his complete opposition to the methods of experimental physics were in general repugnant to the physicists of his time, such as Lichtenberg, and of subsequent times, such as Helmholtz, Tyndall, Arthur Schuster and Wilhelm Ostwald. There are, however, things of value in the "Farbenlehre", as there could scarcely fail to be in a work into which a singularly acute observer had put so much labour. One cause of misunderstanding is that Goethe laid great stress on the colour effects offered by turbid media, such as that provided by a weak suspension of soap in water. The scattered light is bluish, the transmitted light yellowish. Goethe, of course, did not understand the physics of the scattering of light by small particles, which was first cleared up by Tyndall and Rayleigh: furthermore, he would not have accepted the explanation if it had been laid before him, for he held the very methods of mathematical physics in contempt. Neither, however, did the physicists who were Goethe's contemporaries understand the matter—and it is not to be explained on the basis of Newton's optics: if the part of his work which they did understand had not been demonstrably absurd, they might have learnt much from his experiments. Goethe even compared the colour of the sky to the scattering colour of a turbid medium, and so conjectured correctly the cause of the blue of the sky. His explanation, however, was in terms of the simultaneous action of bright and dark, the dark being that of outer space. "If the darkness of infinite space is seen through atmospheric vapours illuminated by daylight, the blue colour appears."

The "Farbenlehre" contains a great number of acute observations of importance in physiological optics, as would be expected from Goethe's whole outlook. Such things as simultaneous contrasts, after-images, coloured shadows and other subjective effects are fully treated and correctly described. The great physiologist Johannes Müller praised the book and expressed himself as greatly indebted to it: Purkinje likewise thought highly of Goethe's work, and dedicated the second volume of his "Beiträgen zur Kenntnis des Sehens" to the poet. We can, in fact, put full faith in Goethe's statements when they are merely descriptive of subjective phenomena and when he does not enter into explanations.

The "Farbenlehre" was the scientific work on which Goethe himself laid most emphasis, but he spent much time and labour on botanical subjects and on his work on comparative anatomy. To certain principles that governed all his work I have already referred: the immense zest, the view of Nature as a poetic whole, the joy in observation, especially in the open air and in the light of Italy. A word must perhaps be said about the importance which Goethe attached to his conception of the fundamental or typical phenomenon, the *Urphänomen*. Thus in colour the *Urphänomen* was the scattering of light in a turbid suspension. In his botanical studies* he likewise sought a fundamental plant, of which all others could be regarded as developments. Among his notes is one "Hypothesis all is leaf and by this simple thing the greatest variety is possible". The thesis of his "Metamorphose der Pflanzen" is that all appendages of the stem are to be regarded as transformed leaves. His theory was not an evolutionary one, in the modern sense, but a comprehensive way of regarding the plant body, a method of interpreting the manifold appearances of vegetable Nature as versions of a fundamental, ideal type. It was not capable of test by systematic study, by observing the actual development of plants, which was, anyhow, not in Goethe's temperament: as he said, *Trennen und Zählen lag nicht in meiner Natur*. Strangely enough, Schiller put his finger at once on the weakness of the theory regarded from the empirical point of view: after Goethe had expounded his great discovery, the other poet remarked *Das ist keine Erfahrung; das ist eine Idee*.

Goethe carried his great general ideas into his studies of comparative anatomy. He considers here again that there is an ideal simple type from which the anatomical details of real animals can be considered as deviations or developments. He was particularly interested in the vertebral column, of which again there was an ideal type. The one discovery with which he was generally credited, that of the intermaxillary bone, was not new. How fantastic some of his speculations were can be illustrated by one example: he states that the tails of animals can be regarded "as an indication of the unending continuity of organic existences"†. He invented the word 'morphology', but it has to-day a significance widely different from that attached to it by Goethe.

In his brilliant and penetrating study of Goethe's science‡, of which a second edition has recently appeared, Sherrington says "Briefly, what was his 'science'? That light is *not* resoluble into coloured lights. That the plant is a collection of modified leaves; that the skull is an adapted piece of backbone—two plausible though superficial conjectures, now, in the fuller light of the cell theory and embryology, set aside; the 'correlation of parts', a clumsy error he misthought a 'law'." It may be that this is a little harsh, especially as regards his botany, but it seems unescapable that the influence of this vast labour, of one of the greatest minds in the history of civilization, on the current of scientific thought is small. There have been attempts to make out that Goethe had general visions of great developments of science that came after him—Helmholtz, though admitting that Goethe's views on the existence of a common type in the animal kingdom had no direct influence on the progress of science, suggests that the famous lines spoken by the *Erdgeist* in "Faust"—the lines beginning "*In Lebensfluten, im*

* Hell und Dunkel, Licht und Schatten
Weiss man klüglich sie zu gatten,
Ist das Farbenreich gesiegt.
Einheit ewigen Lichts zu spalten
Müssen wir für Torheit halten
Wenn euch Irrtum schon genügt.

* It is with misgiving that I, with my pitifully weak knowledge of the subject, say anything of Goethe's botany. A difficulty for me is as Agnes Arber has pointed out, that those scholars who have the fullest and most critical knowledge of his writings differ radically in their estimate of this branch of his science. Those interested should consult Dr. Arber's "Goethe's Botany" (*Chronica Botanica*, Vol. 10, No. 2, 1946), which gives full references.

† Als eine Andeutung der Unendlichkeit organischer Existenzen.

‡ "Goethe on Nature and Science" (Cambridge University Press).

Tatensturm", quoted by Carlyle in Chapter 8 of "Sartor Resartus"—indicate an anticipation of the law of the conservation of energy! Magnus suggests that Goethe's botanical work influenced Jussieu, de Candolle and Robert Brown, a suggestion which I must leave to those more learned than myself in such matters, and, rather half-heartedly, that the foundation of the study of comparative anatomy owes much to Goethe. In some such way it has been suggested that Francis Bacon had a great influence on the work of the early Fellows of the Royal Society, although Bacon's views of the way to set about scientific work were anything but those adopted. It is true, as I have pointed out, that the great physiologists who dealt with colour vision in Goethe's time owed something to him. On the whole, however, it seems to be accepted that, if Goethe had never published anything in science, things would have developed just as they, in fact, did. If Goethe is to be compared to any great figure in the history of science, it must not be to any great modern but rather to Aristotle, whose powers of observation and generalization led him to important advances in the biological sciences while his physics, dominated by philosophical speculation, was not significant. Goethe was a subjective natural philosopher rather than a man of science in the modern sense.

Must we, then, regret that the great man spent so much of his time in fields where his genius produced relatively little of worth? Regrets are, in any case, fruitless, but perhaps they are not even called for. The spectacle of this comprehensive genius attacking such varied problems with such a zest, attempting with such spirit and such confidence to bring a new order into vast fields of knowledge, is an inspiring one. It is well that there shall be seekers after a general light: a stirring up—dust, light and movement—may not be progress, but nevertheless it is occasionally not a bad thing. Be that as it may, in Goethe's activities we see a last attempt—a glorious attempt—to take all culture and all knowledge for one man's province, and we salute it.

RADIOACTIVE TRACERS IN CHEMISTRY

THE scientific programme of this year's anniversary meeting of the Chemical Society was arranged in collaboration with the Chemistry Division of the Government's Atomic Energy Research Establishment. During March 28–30 a symposium on "The Chemistry of the Heavy Elements" and on "Radioactive Tracers" took place in Oxford, and on April 1 a discussion was held in London on "The Use of Radioactive Tracers in Chemistry". The Oxford meeting has already been reported in *Nature* of June 18 and 25.

The London discussions were divided in two parts, the morning session being devoted mainly to tracer applications in inorganic and physical chemistry, the afternoon session to organic-chemical and biological problems. After opening remarks by the president of the Chemical Society, Sir Ian Heilbron, Prof. F. A. Paneth took the chair and introduced the subject by a few general remarks on the steadily growing importance of tracer methods in chemistry since the discovery of artificial radioelements and their production on a large scale. The significance of this new research tool for biological investigations was emphasized by Prof. G. v. Hevesy when he took the chair at the afternoon session.

The question foremost in the minds of many who intend to make use of this technique is, naturally, where and how radioactive tracers can be obtained. It was answered by H. Seligman in his report on "The Availability of Radio-Isotopes". He was able to assure the audience that the Atomic Energy Research Establishment at Harwell is now in a position to provide all the tracers of long life which a year or so ago could only be bought from the United States, and those of shorter life as well, which were previously not obtainable by purchase. A novel feature of the Harwell organisation is a kind of information bureau which tries to help those with little experience in the subject by giving advice as to the tracers likely to be most satisfactory in particular research problems and industrial uses. Equally comforting was the news about the prices, which are kept very low—a point which may be sometimes decisive. It is, therefore, unlikely that any research laboratories within reasonable distance from Harwell will ever be hampered in the use of radioactive tracers by lack of the necessary radioactive material; they might, however, for some while find it more difficult to obtain the equipment of special rooms and high-class modern apparatus, and the staff trained in the new technique.

The other papers dealt with a variety of researches which had only the one feature in common that in the course of the investigation use had been made of a radioactive tracer; for this very reason they do not lend themselves easily to a summarizing review, all the more so as several of the subjects discussed were of a highly specialized nature. All the papers presented at the meeting will be printed in full in the *Journal of the Chemical Society*, and those interested in related problems will find in the complete texts a wealth of helpful information; but in this brief report we can scarcely mention more than the subjects of the contributions and give an indication of the main results.

Since the early days of indicator methods, research workers have found them most useful in the study of diffusion problems. K. E. Zimen, M. Hillert and G. Johannson, in Göteborg, have now employed silver-111 and mercury-203 for a determination of the self-diffusion coefficients of silver and mercury; their paper was read by E. Berne. A second paper from Göteborg, by R. Lindner, reported on work done in Prof. Hedvall's laboratory on the self-diffusion in silver sulphate, lead and zinc oxides. $ZnO.Fe_2O_3$ and $CaO.SiO_2$. That such a study of diffusion coefficients by radioactive tracers can be used as a new means for the investigation of condensation processes in solutions was shown by J. S. Anderson and K. Saddington, of the Atomic Energy Research Establishment, Harwell. From the diffusion coefficients of radioactive sodium tungstate, containing tungsten-185 and -187, it was concluded that with decreasing *p*H there is a progressive aggregation of the tungstate ions; above $pH = 9$, the normal tungstate ion exists, whereas over the range $pH = 2{\cdot}3–5$ a condensed ion is predominant.

Prof. J. W. Irvine, jun., reported on researches carried out by him at the Massachusetts Institute of Technology in collaboration with Prof. C. D. Coryell and W. B. Lewis on the "Electron-transfer (Exchange) between Cobaltous- and Cobaltic-amino Complexes". Cobalt-60 was used as tracer in the cobaltous com-

plex; at suitable time intervals the complex was destroyed by acid, the cobaltous ion extracted quantitatively and its specific activity determined from its gamma-radiation; the specific activity decreases, naturally, if part of the active cobalt enters the cobaltic complex. Complexes containing either ammonia or ethylenediamine were studied, and exchange-rate constants determined.

While in the above papers radioactive tracers were employed in order to study exchange reactions, M. Haïssinsky, from the Institut de Radium, Paris, gave an example of their usefulness in examining the behaviour of chemical elements in extreme dilution. Together with A. Coche, he reported new "Experiments on the Cathodic Deposition of Radioelements". Their results indicate that, contrary to some previous statements, the Nernst electrochemical equation is valid for the bismuth isotope thorium C down to 10^{-13} *N*, and for the lead isotope thorium B to 10^{-10} *N*, if the cathode consists of gold, silver, copper or nickel; they found, however, some anomalies with other electrodes. In the case of polonium, these were attributed to the penetration of polonium atoms into the metal of the cathode.

Before organic-chemical and biological problems were discussed in the afternoon session, J. F. Duncan described studies carried out by himself, G. B. Cook and A. W. Kenny at Harwell on "Techniques in Radiochemical Assay". He issued a warning against possible errors in beta counting, such as those due to multiple counts, variation of high tension or temperature, self-absorption, back-scattering, etc.; fortunately, most of these can be avoided without great difficulty if for the purpose of the experiment only knowledge of the relative values of activities is necessary, and this is the case in the majority of biological applications.

Prof. E. D. Hughes, of University College, London, spoke on "Radioactive Halogens and the Mechanism of Substitution Reactions". He showed how the study of such old problems of classical organic chemistry as the mechanism of replacement, racemization and Walden inversion can be helped by the radioactive technique; in the cases considered, it could be shown that bond-formation and bond-fission occurred synchronously.

Biochemical problems were discussed by the last four speakers. In their "Studies with Radioactive Penicillin", S. Rowlands, D. Rowley and E. Lester Smith, of the University of Edinburgh, prepared penicillin labelled with sulphur-35 by growing the mould on a medium containing activated sulphate. The penicillin obtained was sufficiently active to make it possible to follow up its fate in experimental animals. It was found that, if injected intramuscularly, 100 per cent of it was excreted with the urine. On the other hand, if bacteria were killed with the activated penicillin, no active sulphur could be detected in them, which proved that less than ten molecules of penicillin had been taken up by a bacterium.

F. D. S. Butement, of the Atomic Energy Research Establishment, Harwell, showed in his paper on "Radioactive Tracers in Antisera" how the study of problems of immunology can be refined. He succeeded in introducing iodine-131 into the globulin fraction of antiserum without destroying its specific agglutinating properties; the amount of iodine activity carried on *Proteus vulgaris* when agglutinated by the specific antiserum could be used to measure the agglutinin.

From the University of Saskatchewan came a paper by Prof. J. W. T. Spinks and G. Dion on the "Study of Fertilizer Uptake using Radio-Phosphorus"; it was read by R. Spence. The authors made use of phosphorus-32 to measure the uptake of fertilizer phosphorus and soil phosphorus by wheat plants; as fertilizers they employed, in field and in greenhouse experiments, ammonium-, sodium- and calcium-phosphates. Their results showed, among other facts, that in the early stages of growth practically all the phosphorus taken up comes from the fertilizer, while during the later stages the phosphorus uptake from this source is relatively small.

In his report on "Some Chemical Problems in the Use as a Fumigant of Methyl Bromide Labelled with ^{82}Br", F. P. W. Winteringham, from the Pest Infestation Laboratory, Slough, demonstrated a new way in which the fate of the fumigant can be followed up in treated foodstuffs and in infesting insects. It concluded a well-attended and very successful discussion meeting. F. A. PANETH

PROGRESS IN HIGH-SPEED CALCULATING MACHINE DESIGN

A CONFERENCE on high-speed automatic digital calculating machines was held in the University Mathematical Laboratory at Cambridge during June 22–25 to mark the completion of the EDSAC (electronic delay storage automatic calculator).

The EDSAC is a serial binary machine based on the ideas put forward in an unpublished report circulated in 1945 by von Neumann on behalf of the group working at the Moore School of Electrical Engineering in Philadelphia, where the ENIAC—the first electronic calculating machine ever built—was at that time under construction. The EDSAC is believed to be the first complete machine of its kind to be put into operation, although a slightly smaller machine, without automatic input and printing devices, has been built at the University of Manchester. This machine was described to the conference by Prof. F. C. Williams and Dr. T. Kilburn. Several machines are nearly completed in the United States. Information about these was given in a paper communicated by Dr. H. D. Huskey (National Bureau of Standards).

In the EDSAC, ultrasonic delay units are used for storage, the total capacity for orders and numbers (each with sixteen binary digits—equivalent to five decimals) being 1,024. There are facilities for combining two adjacent storage locations so as to hold a number with the equivalent of ten decimal digits. The programme of orders and any numerical data required are fed into the machine from a punched tape, and the results of the calculation are printed automatically on a teleprinter. The EDSAC was demonstrated to members of the conference by the writer and Mr. W. Renwick.

The EDSAC and the machines like it are a great advance on the ENIAC in that they are very much smaller and yet have greater storage capacity for numbers. Most people will, however, agree that electronic calculating machines are still too large—the EDSAC has more than three thousand valves—and that one of the primary aims of future research must be to reduce their size. In the present writer's

view, this is at present more important than attempting to achieve the maximum speeds which are possible using electronic methods. Reliability of operation and the rapidity with which faults may be located depend on size and, as Dr. H. H. Aiken, director of the Computation Laboratory of Harvard University, is fond of pointing out, the overall speed of operation depends as much on these factors as on the intrinsic operating speed. It was unfortunate that Dr. Aiken was not able to attend the conference, since developments in his laboratory are proceeding along rather different lines from those indicated in this article.

The component parts of an automatic computing machine are: control, store, input–output unit, and arithmetical unit. The arithmetical unit usually provides for addition, subtraction and multiplication, and perhaps for division. It may also include special devices for extracting square roots, for evaluating sines and cosines, and for other similar functions. Since the whole of arithmetic can be reduced to addition and subtraction, it is strictly only necessary to provide for these two operations; multiplication, for example, is then done by a programmed series of additions. There must, of course, in any automatic machine, be provision for some kind of conditional order by which, at any given stage in the calculation, the action of the machine may be made to depend on the results of previous calculations.

So far as the writer is aware, no full-scale machine which does not include a multiplier has been proposed, although the first experimental machine to be built at Manchester had provision for subtraction only; on this machine even addition had to be programmed as two subtractions. On the other hand, judging by the discussions which took place at the conference, few designers would now wish to provide special equipment for the evaluation of square roots and special functions, and many would not provide a divider, preferring to rely on the use of an iterative formula involving multiplication and addition only.

The disadvantage of providing specialized equipment for particular functions is that the machine is thereby made more complicated than it need be. The main advantage is that the operating speed can be increased. For example, a programmed multiplication on the EDSAC would take about 0·5 s. compared with 5 ms. for the built-in multiplier. Most of this time is spent in waiting for orders and numbers to come out of the delay-type store, and, if a store from which any order or number could be obtained within a few microseconds were available, a machine without an automatic multiplier would be a practical proposition. Mr. J. H. Wilkinson (National Physical Laboratory), in opening a discussion on programming, pointed out that, even with an ultrasonic delay store, if orders and numbers are so located that they become available just when required, the time for a programmed multiplication can be reduced to about 16 ms. as compared with 3 ms. for a built-in multiplier. These figures apply to the ACE, a machine for which a pilot model is now being built at the National Physical Laboratory. This loss of speed is a price which might very well be paid for the resulting simplification of the arithmetical unit.

One further advantage of providing separate equipment for specialized functions is that it simplifies programming and hence makes the machine easier to use. This advantage is not, however, so substantial as at first sight appears. The reason is as follows. The programme for a practical problem will normally be constructed by assembling a number of ready-made 'sub-routines' drawn from a 'library' associated with the machine. The library will include a sub-routine for evaluating square roots, one for evaluating sines, etc. Apart from other considerations, experience at Cambridge has shown that, if sub-routines are not used, it is quite difficult to construct a long programme which is free from accidental errors. Once a sub-routine has been incorporated in a programme it can be called in whenever it is required by a short group of orders. The work of constructing a sub-routine can be compared to that of building a piece of equipment for performing the same function. For example, one can either employ an engineer to construct a device for evaluating square roots, or a mathematician to design a sub-routine, based on the four rules of arithmetic, for the same purpose. In either case, the work is done once for all, and the degree of convenience for the ultimate user is much the same. The difference is that the mathematician's work will not need any maintenance, whereas the engineer's will. A machine which makes use of sub-routines instead of specialized units will, of course, need slightly greater storage capacity in order to hold the necessary orders, and this fact must not be forgotten when assessing the relative advantages of the two systems.

Most of the automatic calculating machines now being designed make use of the binary scale for all internal calculations, conversion to and from the decimal scale being done during input and output by means of a sub-routine. Prof. D. R. Hartree expressed the view that this is a passing phase and that designers will revert to the use of the decimal system throughout. While agreeing that this may perhaps be so, the writer would wish to draw a distinction between decimal machines constructed from elements with two stable states, such as 'flip-flops', and those constructed from elements with ten stable states such as counter wheels. The former can be described as 'disguised binary' machines, and it would appear that they will always be less economical in equipment than pure binary machines.

The choice between having complications in the machine or complications in the programme arises also when methods of checking are considered. Dr. A. M. Uttley (Telecommunications Research Establishment) put the case for building into the machine a complete series of checking circuits so arranged that the machine will stop the moment any element fails to operate correctly; if necessary, he would be prepared to increase the size of the machine by 50 per cent for this purpose. Mr. S. W. Noble and Mr. R. H. A. Carter described some three-state trigger and adding circuits which have been developed at the Telecommunications Research Establishment for use in a machine in which a positive indication is to be provided for both 0's and 1's. The case for relying on mathematical checks incorporated in the programme was put by Mr. D. J. Wheeler (Mathematical Laboratory, Cambridge) and supported by Prof. F. C. Williams (University of Manchester) and Dr. J. C. P. Miller (Scientific Computing Service).

Mr. E. N. Mutch (Mathematical Laboratory, Cambridge) opened a discussion on permanent and semi-permanent storage facilities for sub-routines and numerical data. Punched paper tape and celluloid film on which records are made photographically or mechanically and read by photo-electric means are examples of methods of permanent storage; magnetic

recording on wire, tape or a drum is semi-permanent. Mr. G. E. Thomas described a magnetic-drum system in use in Manchester, and Mr. A. Tutchings spoke of some work in progress at the Telecommunications Research Establishment.

When a sub-routine is incorporated in a programme, it is often necessary to modify some of the orders according to their location in the main programme. Mr. Wheeler described how this is done at Cambridge; at the time the sub-routines are taken into the machine, the orders are modified by means of a sequence of 'co-ordinating orders'. Dr. Kilburn and Prof. M. H. A. Newman explained a different system used in the machine at Manchester, where an extra adding circuit is associated with the control system in such a way that one of two numbers (as the programmer may choose) can be added to the numerical part of each order (the address) before it is executed.

Much of what has been said about electronic machines applies also to relay machines; but since a single relay can carry a number of contacts, and since problems of interaction are not so serious as with valves, more elaborate circuit arrangements are possible without increasing the size of the machine unduly. On the other hand, relays suffer from contact bounce and from transient faults caused by dust between the contacts.

Miss K. H. V. Britten (British Rubber Producers' Research Association) presented, on behalf of Dr. A. D. Booth (Birkbeck College, London), a paper on relay machines, and described the automatic relay calculator which is now nearly completed. This is a parallel binary machine with a magnetic-drum store, and is notable for its small size; it contains only about eight hundred high-speed relays. Numbers contain twenty binary digits and a sign digit. Dr. A. van Wijngaarden described a somewhat similar machine under construction at the Mathematische Centrum at Amsterdam. Dr. S. H. Hollindale gave some information about a relay machine being built at the Royal Aircraft Establishment. This is a true decimal machine, using stepping switches for the registers, and has a floating decimal point. Another relay machine, under construction in Sweden, was described by Mr. G. Kjellberg. M. V. WILKES

NEWS and VIEWS

Newcastle upon Tyne and District

IN preparing a handbook for members of the British Association attending the Newcastle meeting, the local committee has reverted to the older scheme of a publication embracing all aspects of natural history and botany as well as industries of the city and district entertaining the Association. "The Scientific Survey of North Eastern England", which is to be given to each member attending the meeting, is most successful and should find ready acceptance. Physiography, geology and climate are specially notable, while iron and steel, shipbuilding and engineering, of course, command full notice. Broadly speaking, the area covered is Northumberland and Durham, with the northern part of the North Riding of Yorkshire, which Prof. G. H. J. Daysh, who writes an introductory note, points out is a clearly defined region with a character and individuality of its own, though with great and contrasting interests within its boundaries. At least two new towns, Newton Aycliffe and Peterlee, fall within the programme of development of the region. The survey is well documented and has adequate maps, including an ingenious one showing forms of rural and urban buildings in the area.

Sir Gilbert Blane (1749-1834)

GILBERT BLANE was born at Blanesfield, Ayrshire, on August 29, 1749. After studying at Edinburgh and graduating M.D. at the University of Glasgow in 1778, he sailed to the West Indies in 1779 as private physician to Admiral Lord Rodney. His ability and coolness in action won him the Admiral's friendship and the appointment of physician to the Fleet. On his return to London he was elected physician to St. Thomas's Hospital. When Blane was a boy of four, James Lind recommended the use of fresh fruit and vegetables for the prevention of scurvy. At forty-seven, Blane, as commissioner for sick and wounded seamen, succeeded in getting Lind's pioneer suggestion officially adopted by the Admiralty. The disease at once disappeared from the official sick-returns. Other naval reforms effected by Blane were the ventilation and cleansing of ships, the supply of soap and medical necessities, and the introduction of hospital ships to take the place of shore hospitals. He also advised on quarantine legislation, on the prevention of prison fever, and on many other public health problems. He became a baronet in 1812 after his return from Walcheren, where he had arranged for the transport of the sick following government acceptance of his advice to withdraw the disease-stricken troops from that unhealthy island. Physician-in-ordinary to George IV, and a Fellow of the Royal Societies of London and Edinburgh, his most important book was "Observations on the Diseases Incident to Seamen" (1785). Blane's health began to fail in 1821, and he died on June 27, 1834. Because of his austerity he was nicknamed "Chilblain"; but in the annals of history he lives as the 'Father of Naval Medical Science', whose memory is honoured by the Royal College of Surgeons in the annual award of the Blane Gold Medal.

Standardization

AT the recent forty-eighth annual general meeting of the British Standards Institution, the president, Lord McGowan, referred to the greatly increased interest during the past year, both by industry and Government, in the extension of voluntary standardization on a national basis. Under the chairmanship of Sir Ernest Lemon, the investigations by the committee for standardization of engineering products, which was set up by the Ministry of Supply, have substantiated the view, long held by British industry, that the principles under which the British Standards Institution works are effective and can be considerably extended. The Anglo-American Productivity Council has recently stressed the importance of standardization and simplified practice, and Lord McGowan submitted that there is probably no more effective means for increasing productivity. Another significant development during the past year has been the co-operation of the great nationalized

industries with the Institution, and the increase in the collaboration among large industrial users with the view of assisting manufacturers to reduce the number of types and sizes. This progressive standardization will greatly assist the economy of Great Britain by enabling manufacturers to introduce longer runs and better production methods in their operations. In conclusion, Lord McGowan said that the British Standards Institution is the pioneer national standards organisation, and collaborates with thirty-four other standards bodies overseas, and that with the continued growth in the number of export and import controls exercised by various countries national standards are becoming increasingly important.

New Theory on the Earth's Interior

Sky and Telescope of February contains a brief account of the theory of R. B. Borcherds which he advocated in his address as retiring chairman of the Cape Centre of the Astronomical Society of South Africa. This theory suggests that the characteristics of the earth's interior can be described on the basis of variations in condition rather than composition. Assuming a temperature-gradient of one degree for every 90 ft. of depth, he finds that the observed discontinuities in the transmission of earthquake waves at depths of 7½, 23 and 38 miles can be attributed to changes of state due to high temperature and pressure. He describes a transitional region between 750 and 1,800 miles within which depths the temperature and pressure are estimated to increase respectively from 44,000° to 105,000° C., and from 5,150,000 lb. to 12,300,000 lb. per square inch. The pressure at the centre of the earth is calculated at 50 million pounds per square inch, and in such circumstances an ounce of hydrogen would be compressed into 0·001 to 0·003 of a cubic foot. If 100,000° is above the critical temperature for any of the known elements, no pressure applied to these substances at this temperature would cause them to liquefy or solidify; hence he considers that the earth's centre is gaseous, although highly compressed. The gas would be ionized and compounds would produce much higher densities than the known average of 5·52 for the earth. He thinks that iron would lose its magnetic properties under the intense heat at the earth's centre, so the old iron-nickel theory of the earth's core, developed to explain the earth's magnetic properties, cannot be sustained, and in any event is unnecessary if rotating bodies develop magnetism, as has been recently found for stars.

Aeronautical Quarterly

THE Royal Aeronautical Society has produced the first issue (May) of a new publication called the *Aeronautical Quarterly*. The purpose of the journal is to make available reports on new and original work of a scientific nature, and also papers reviewing progress in the various specialized branches of the application of fundamental aeronautical science. The Council of the Society feels that the development of aeronautical science and engineering has now become so rapid that the means of disseminating the knowledge acquired are inadequate; it is intended that the papers in the new journal will present results of original work done in Government research establishments, universities and the industry, not always suitable for presentation before the Society's meetings. Under the terms of its charter the Society is charged, among other things, "to facilitate the exchange of information and ideas amongst the members of the Society and others", and the editorial board expresses the hope that workers will be encouraged to submit details of their researches, so that the results may be available to others concerned with the development of the many aspects of aviation. A distinguished Editorial Board with the necessary editorial executives have been appointed, and they are advised by panels of referees upon aerodynamics (general, fluid motion, and stability and control), structures, materials, aircraft design, instrumental and electrical equipment, vibration and flutter, aircraft propulsion, air transport, meteorology, flight testing, helicopters and propellers, aircraft accessories, fuels and oils, aviation medicine, performance, and radio and radar. The publication will be available to the public, and contributors need not necessarily be members of the Society.

The Film in Further Education

IN 1946 the Yorkshire Council for Further Education appointed a sub-committee to consider "the use of films in courses held under regulations for Further Education". The sub-committee was made up of representatives of film, theatrical, voluntary and educational organisations. The sub-committee's report has now been published and contains much useful information about the educational, technical and administrative questions which govern the use of the film and filmstrips in various branches of continued education. In the first part of its report the sub-committee discusses the evolution of the film as an educational medium and the uses to which the motion film, filmstrip and lantern slide may be put in educational classes. The second part makes practical suggestions to authorities on how to obtain and make available suitable equipment and material under proper conditions at the proper time and place, at a reasonable cost, and how to train teachers and leaders in their proper use. Because of its concern at the relatively small attention which is given by those concerned with further education to the development of higher standards of criticism and discrimination in connexion with the cinema, the sub-committee has also prepared a section dealing with film appreciation in youth clubs and the organisation of film discussion groups. The appendix contains a valuable bibliography and a list of addresses which will be particularly useful to those beginning classes in film appreciation. Copies of the report may be obtained from 35 Park Square, Leeds, 1, price 1*s*. 9*d*.

Faraday Society Discussion on Chromatographic Analysis

THE Faraday Society is arranging a general discussion on chromatographic analysis to be held in the Department of Chemistry, University of Reading, during September 22–24. As is usual at the Society's discussions, a number of foreign visitors will be contributing, the countries represented including Sweden, Holland, Italy, Norway, Switzerland and the United States. The papers have been grouped in two sections covering physicochemical principles and applications respectively. Papers will be issued in advance and taken as read, authors being allowed five minutes to emphasize particular points; general discussion will follow. It is hoped to issue papers and discussion as a separate publication in due course. Particulars of the meeting can be obtained from the Secretary, Faraday Society, 6 Gray's Inn Square, London, W.C.1.

Conference on Industrial Safety

A RESIDENTIAL conference, to be held at the Royal Hotel, Scarborough, during October 7–9, is being organised, on behalf of the Association of British Chemical Manufacturers, by the Royal Society for the Prevention of Accidents, to discuss the safe use of solvents, the installation and maintenance of breathing apparatus, and the use of electrical apparatus in hazardous atmospheres, and similar topics. Sir Harry Jephcott, of Glaxo Laboratories, Ltd., will open the conference, and other speakers will include Dr. A. J. Amor, president of the Association of Industrial Medical Officers; Mr. T. Senior, of Imperial Chemical Industries, Ltd.; and Mr. S. W. Richards, of the General Electric Company, Ltd. Application forms and full particulars can be obtained from the Royal Society for the Prevention of Accidents, Industrial Safety Division, 131 Sloane Street, London, S.W.1.

Conference on Foundry Steel Melting

THE Steel Castings Division of the British Iron and Steel Research Association announces that a conference on foundry steel melting will be held during September 22–23 at Ashorne Hill, Leamington Spa. The technical and economic aspects of the various processes and their relative merits will be discussed. Following the same procedure as the three previous successful conferences organised by the Steel Castings Division, the conference will consist of four sessions, dealing with the cupola/converter process, electric arc process, other melting processes and general topics, respectively. Application forms for accommodation at Ashorne Hill may be obtained from the Steel Castings Division of the British Iron and Steel Research Association, 11 Park Lane, London, W.1.

Textile Institute Awards

THE Textile Institute has awarded a £1,000 open scholarship to Geoffrey Robert Haines, aged nineteen, an engineering workshop apprentice at Redditch Technical School, Worcs. This is the first such scholarship offered by the Institute to young persons in any section of the textile industry and to senior students in their final year at school. The award will enable Mr. Haines to take a degree course in textile engineering at the Manchester College of Technology.

A further £750 Cotton Industry War Memorial Trust Scholarship—the seventh—has been awarded by the Institute to John Clifford Hilton, aged twenty-one, a designer at Thos. Moss and Sons, Ltd., Lostock Hall, nr. Preston. Mr. Hilton will complete preparatory studies at the Preston Harris Institute before proceeding to a degree course at the Manchester College of Technology.

Medical Research Council: Travelling Awards

THE Medical Research Council announces that it has made the following travelling awards for the academic year 1949–50. *Rockefeller Travelling Fellowships in Medicine:* Mr. W. J. Atkinson, Mackenzie Mackinnon Research Fellow (Royal College of Surgeons), National Hospital, Queen Square, London; Dr. Ruth E. M. Bowden, lecturer in anatomy, Royal Free Hospital School of Medicine, London; Dr. R. Daley, first assistant, Cardiology Department, St. Thomas's Hospital, London; Dr. J. Dawson, lecturer in biochemistry, University of Leeds; Dr. C. E. Lumsden, senior lecturer in pathology, University of Aberdeen; Dr. J. S. Robson, assistant, Departments of Medicine and Clinical Biochemistry, University of Edinburgh. *Dorothy Temple Cross Research Travelling Fellowships in Tuberculosis:* Dr. A. J. Robertson, medical registrar, Royal Infirmary, Liverpool; Mr. J. D. Wade, surgical officer, Welsh National Memorial Association (Sully Chest Centre). *Travelling Scholarships under an exchange arrangement with the Centre National de la Recherche Scientifique in France:* Dr. E. J. Field, lecturer in anatomy, University of Bristol; Miss A. M. N. Sewell, Nuffield Research Unit, Psychological Laboratory, University of Cambridge.

The Night Sky in September

FULL moon occurs on Sept. 7d. 09h. 59m., U.T., and new moon on Sept. 22d. 12h. 21m. The following conjunctions with the moon take place: Sept. 3d. 04h., Jupiter 5° N.; Sept. 18d. 22h., Mars 4° S.; Sept. 21d. 08h., Saturn 2° S.; Sept. 23d. 17h., Mercury 4° S.; Sept. 25d. 10h., Venus 1° N.; Sept. 30d. 10h., Jupiter 5° N. Mercury is an evening star during the first part of the month and later becomes a morning star, but is too close to the sun for favourable observation. Venus sets about an hour after the sun and can be seen in the western sky, stellar magnitude −3·5, the visible portion of the illuminated disk being between 0·790 and 0·707. Mars rises just after 1h. during the month and can be seen for a few hours before sunrise. Jupiter is visible in the earlier portion of the night, setting at 1h., 0h. and 23h., approximately, at the beginning, middle and end of the month, respectively; the planet is stationary on Sept. 17. Saturn is in conjunction with the sun on Sept. 2 and cannot be observed. Occultations of stars brighter than magnitude 6 are as follows: Sept. 14d. 00h. 35·1m., 36 Tauri. (*R*); Sept. 16d. 00h. 05·3m., 136 Tauri. (*R*); Sept. 18d. 04h. 15·1m., ω Canc. (*R*). *R* refers to reappearance and the latitude of Greenwich is assumed. Autumnal equinox occurs on Sept. 23d. 09h.

Announcements

THE Research Fund of the Chemical Society provides grants for the assistance of research in all branches of chemistry. About seven hundred pounds per annum is available for this purpose, the income being derived from a donation of the Worshipful Company of Goldsmiths, from the Perkin Memorial Fund, and from other sources. Application forms, obtainable from the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1, should be submitted not later than November 1. Applications from Fellows of the Society will receive prior consideration.

WE have received from Messrs. J. Barcham Green, Ltd., Hayle Mill, Maidstone, a sample box of 'Hyduro' filter papers, which have a low ash-content and withstand pressure-filtering or severe washing without bursting. The particular papers examined were double acid-washed, with an average ash per circle of 0·00020 gm., and suitable for use with the filter pump for slow filtration with fine precipitates. Other grades are obtainable, one being specially hardened to stand pressures of 30–50 lb. wet, which is quite outstanding.

CONDUCTIVITY AND THERMO-ELECTRIC EFFECT IN CUPROUS OXIDE

By N. N. GREENWOOD* and Dr. J. S. ANDERSON†
Chemistry Department, University of Melbourne

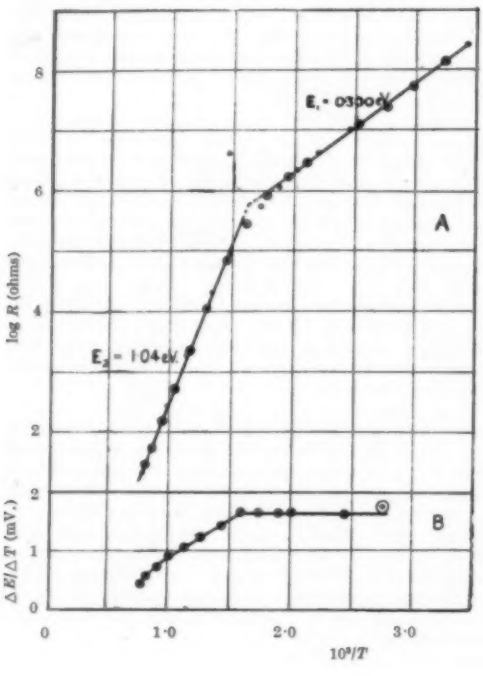
IN measurements of the semiconducting properties of stannous sulphide, described some time ago[1], it was found that the thermo-electric power was independent of the temperature over the temperature range where the material displayed positive-hole impurity conduction. We have recently completed a study of cuprous oxide, between the ordinary temperature and 1,000° C., and find that its behaviour is similar.

Cuprous oxide has been the object of numerous investigations, and our work is comparable, in particular, with that of Russian workers[2,3]. In adding to existing data, we have sought to characterize the oxide uniquely, by bringing it into equilibrium with free metallic copper at 1,050° C.; the composition of the oxide is thereby fixed at the metal-rich end of the range of compositions over which the cuprous-oxide phase exists. The material defined in this way was fairly reproducible in its characteristics; the thermo-electric effect showed it to be still a positive-hole conductor. The residual concentration of impurities, calculated on the basis of the Fowler–Wilson theory and Engelhard's data for electron mobilities, appeared to be very small (less than 10^{-10} gm.-atoms oxygen per mole of cuprous oxide), but the validity of such a calculation is dubious.

The conductivity–temperature relation is represented by curve *A*. As is usual, two distinct processes can be recognized, at high temperatures and low temperatures respectively. The conduction characteristics of three specimens are summarized in the accompanying table (i–iii). These specimens differed somewhat in their thermal history, and the differences between them, especially in the low-temperature region, are probably due in part to variation in residual impurity content. Their properties are closely similar to those of the material used by Schottky and Waibel for measurements of the Hall coefficient[4] (see table, iv). The cuprous oxides studied by Wagner *et al.*[5] had a smaller high-temperature activation energy (0·7 eV.), but had not been subjected to drastic deoxygenation. In work which has frequently been quoted, Jusé and Kurtschatow[2] did endeavour to remove the stoichiometric excess of oxygen progressively and completely, but their value for E_2 (0·72 eV.) is, we believe, typical of oxide containing some stoichiometric excess of oxygen. It must, however, be recorded that none of our specimens yielded a conductivity curve such as they report, extending without discontinuity over the entire range from high temperatures downwards.

$$\kappa = A_1.\exp(-E_1/kT) + A_2.\exp(-E_2/kT)$$

Specimen	Low-temperature range		High-temperature range	
	A_1	E_1 (in eV.)	A_2	E_2 (in eV.)
i Preliminary	0·23	0·26	$2·04 \times 10^4$	0·91
ii *A*	0·0033	0·24	$3·30 \times 10^4$	0·99
iii *B*	0·26	0·30	$2·04 \times 10^4$	1·04
iv Schottky and Waibel	2·4	0·42	$7·1 \times 10^4$	1·13



The relation between thermo-electric power (measured on the same specimens, and at the same time as the conductivity) and temperature also falls into two segments (curve *B*), the temperature of discontinuity agreeing closely with the break in the conductivity curve. Below about 350° C. the thermo-electric power, although dependent on oxygen content and past thermal history, is quite independent of the temperature (± 1 per cent) over a considerable range (in agreement with Hochberg and Kvascha[3]). At higher temperatures the thermo-electric power decreases with rise of temperature, but the effect is that of a positive-hole conductor up to the highest temperatures. This may be contrasted with the case of stannous sulphide, for which a reversal of sign indicated the change from positive-hole conduction to electron (intrinsic) conduction. Schottky and Waibel reported that the Hall coefficient of their cuprous oxide changed its sign at 500°, but none of our specimens paralleled this in their thermo-electric behaviour. The high-temperature variation of the thermo-electric power is fairly reproducible from specimen to specimen; it could be represented by several alternative temperature functions.

These measurements confirm the conclusion drawn previously, that the thermo-electric properties of impurity semiconductors are not adequately described in the present state of semiconductor theory. Al-

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though Mönch's full discussion[6] of the thermo-electric effect in terms of the Fowler–Wilson model received apparent confirmation from his own measurements on cuprous oxide over a small temperature-range around room temperature, his results cannot be directly compared with ours. His specimens had a much higher conductivity (higher oxygen content), and their chemical state and inner equilibrium were not closely defined. The treatment more recently developed by Lark-Horowitz *et al.* appears satisfactorily to reproduce the behaviour of a semiconductor for which the ionization energy of impurity centres is so small that the concentration of impurity electrons (or positive holes) becomes effectively constant at moderate temperatures. If, as with cuprous oxide (see table) or stannous sulphide, E_1 is not very small, so that the concentration of current carriers is changing continuously with temperature, it would seem inescapable that the thermo-electric power should be a function of temperature. Nevertheless, for two semiconductors with a low concentration of impurity centres, it has been definitely established that the thermo-electric power is independent of temperature between room temperature and the onset of high-temperature conduction processes. Extension of measurements to low temperatures (that is, below room temperature) is impracticable, because of the high resistivity of such materials.

We would interpret the high-temperature limb of the accompanying graph as representing the intrinsic conductivity of cuprous oxide. If the observations are evaluated in terms of the usual expression for extrinsic conductors, the concentration of impurity centres appears to be comparable with the total concentration of copper atoms: that formula is, in fact, not valid. On the alternative assumption of intrinsic conduction, the mobility of the current carriers can be calculated. This is far greater (of the order of 1,000 cm./sec./volt/cm.) than was found by Engelhard for material of higher impurity content at the ordinary temperature, but is paralleled by the mobility of electrons in germanium of low impurity content, as found by Ringer and Welker[7].

It remains to interpret the permanent positive sign of the thermo-electric effect, and also the fact clearly established by Wagner, that the total conductivity of cuprous oxide at high temperatures varies with oxygen pressure in the manner required of an impurity conductor. For material of 'limiting' composition, at high temperatures, the concentration of positive holes and of conduction electrons would be nearly equal; but the small preponderance of positive holes would be substantially increased in the presence of an appreciable partial pressure of oxygen, when the impurity concentration is 10^{-4} to 10^{-3}. The thermo-electric power involves both the number and the mobility of each conducting species. Our results for nearly stoichiometric cuprous oxide must imply that the ratio (mobility of electrons) to (mobility of positive holes) cannot be greatly in excess of unity. A higher ratio (*cf.* 3) has been cited for electrons and positive holes in germanium.

[1] Anderson and Morton, *Trans. Farad. Soc.*, **43**, 185 (1947).
[2] Juse and Kurtschatow, *Phys. Zeit. Sowjetunion*, **2**, 453 (1932).
[3] Hochberg and Kvascha, *J. Exp. Theor. Phys.* (*U.S.S.R.*), **5**, 41 (1935).
[4] Schottky and Waibel, *Phys. Z.*, **34**, 858 (1933); **36**, 912 (1935).
[5] Dünwald and Wagner, *Z. phys. Chem.*, B, **17**, 467 (1932); B, **22**, 212 (1933). Gundermann and Wagner, *ibid.*, B, **37**, 157 (1937). Gundermann, Hauffe and Wagner, *ibid.*, B, **37**, 148 (1937) Wagner and Hammen, *ibid.*, B, **40**, 197 (1938).
[6] Mönch, *Z. Phys.*, **83**, 247 (1933); *Ann. Phys.*, **26**, 481 (1936).
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ULTRASONIC ABSORPTION IN WATER IN THE REGION OF 1 mc./s.

By C. E. MULDERS

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THE absorption of ultrasonic waves in liquids has been the subject of many investigations. In particular, many measurements have been made of the absorption in water as a function of the temperature and frequency. For frequencies of 5 mc./s. and more, the latest published results for water agree well and seem to be accurate[1]. If α is the absorption coefficient and f the frequency, α/f^2 is found to be independent of the frequency and is 21×10^{-15} m.$^{-1}$/sec.^{2} at 25° C. For frequencies near 1 mc./s. the absorption coefficient is approximately 0·2 db./m. This is too small to be measured accurately by the known methods.

We have tried to determine the absorption for these frequencies by a reverberation method. This method has been used by Knudsen[2] for the determination of the ultrasonic absorption in several gases and by Meyer[3] for liquids.

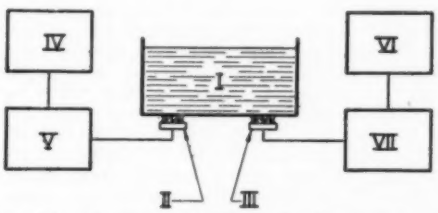

Fig. 1. Schematic arrangement of the reverberation measurements. I, Liquid; II, quartz crystal; III, Rochelle salt crystal; IV, automatic on-off switch for generator; V, frequency-modulated H.F. generator; VI, apparatus for the measurement of the reverberation time; VII, amplifier

A cylindrical aluminium vessel is filled with water (Fig. 1); ultrasonic waves are generated in the liquid by a piezoelectric crystal, coupled to a high-frequency generator. A second crystal acts as a microphone. Both crystals are coupled acoustically to the bottom of the vessel by a drop of kerosene.

After the sound-source has been stopped, the sound in the vessel reverberates. The reverberation-time can be measured at the output of the microphone amplifier. The reverberation-time, defined as the time constant of the decay of the sound-amplitude, is of the order of 10 milliseconds in water for 1 mc./s. Fluctuations in the reverberation can be diminished by using frequency-modulated signals, and so an accuracy of a few per cent can be reached.

However, the measured damping is produced not only by the absorption in the liquid, but also by other causes, for example, radiation into the air, friction along the walls, etc.

If the vessel is wholly filled with liquid, the following formula for the reverberation time T, or attenuation constant $\delta = 1/T$, can be deduced:

$$\frac{1}{T} = \delta = \alpha c + \frac{2}{3}\sqrt{\pi}\left(\frac{2}{R} + \frac{1}{H}\right)\sqrt{\frac{f.\eta}{\rho}} + \frac{143}{\rho H} + \frac{A}{\pi R^2.H} \qquad (1)$$

where α is absorption coefficient of the liquid; c is velocity of propagation of sound in the liquid; R is radius of the cylindrical vessel; H is height of the vessel; f is frequency; η is ordinary coefficient of viscosity (shear viscosity); ρ is density of the liquid; A is a constant.

The first term of the right-hand side of this equation indicates the absorption in the liquid. The second term indicates the losses caused by friction along the walls and bottom of the vessel. The third term indicates the losses caused by radiation into the air from the liquid surface. The fourth term indicates the losses caused by conduction to the crystals attached to the bottom.

The third and fourth terms are small. Only the second term is important. This term is deduced in a manner analogous to the one in which the losses by friction of acoustical waves in tubes can be calculated[4]. Two assumptions are made: (1) the sound energy is distributed homogeneously in the vessel; (2) the walls of the vessel behave as rigid walls. The second assumption seems strange, for the material of the walls is aluminium, 1–2 mm. thick. However, it can be proved experimentally in a direct way, or by the ultimate validity of equation (1). For the same reason, too, the losses in the material of the wall itself are negligible. Moreover, the absorption coefficient of aluminium is small[5].

As an experimental control, the absorption coefficient for water at 25° C. has been determined for three frequencies, 750, 1,010 and 1,500 kc./s., by measuring the reverberation time in aluminium vessels. Two vessels were available, both with $R = 14$ cm. and $H = 10$ cm.; the walls were 1 mm. and 2 mm. thick respectively. The measured reverberation-time was independent of the thickness of the wall, as may be expected from equation (1). The results, with the corrections from equation (1), and the resulting value of α are given in the accompanying table.

Reverberation measurements in aluminium vessel filled with water of 25° C.

	Units	Frequency in kc./s.		
		750	1010	1500
Meas. reverb. time T	sec. 10^{-3}	24·0	17·1	9·8
$\frac{1}{T} = \delta$	sec.$^{-1}$	41·5	58·5	102·0
$\frac{2}{3}\sqrt{\pi}\left(\frac{2}{R}+\frac{1}{H}\right)\sqrt{f\eta}$	sec.$^{-1}$	22·5	26·0	32·0
$\frac{143}{\rho H}$	sec.$^{-1}$	1·5	1·5	1·5
$\frac{A}{\pi R^2 . H}$	sec.$^{-1}$	0	0	0
αc	sec.$^{-1}$	17·5	31·0	68·5
α	m.$^{-1}$ 10^{-3}	1·17	2·06	4·45
α/f^2	m.$^{-1}$ sec.^{2} 10^{-15}	21	20·5	20

The correction terms are calculated as follow: $R = 0{\cdot}14$ m.; $H = 0{\cdot}10$ m.; $\eta = 0{\cdot}89 \times 10^{-3}$ N m.$^{-2}$ sec.; $\rho = 1{,}000$ kgm. m.$^{-3}$; $c = 1{,}500$ m.sec.$^{-1}$. The values found in this way show that α/f^2 is independent of the frequency in this region. They correspond quite well with the values for α/f^2 found by several investigators for higher frequencies[1] (5 mc./s. and upwards).

In Fig. 2 the calculated and measured values for $\delta = 1/T$ are given for three vessels, with $R = 14$, 10 and 8 cm. and $H = 10$, 7·2 and 6 cm. respectively, filled with water of 25° C., as a function of the value

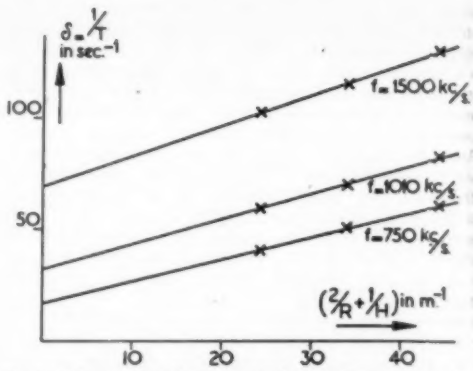

Fig. 2. Values of the attenuation constant (reciprocal of reverberation time) for vessels filled with water of 25° C. for three frequencies as function of the dimensions of the vessels. ———, calculated values. ×, measured values

of $\left(\frac{2}{R}+\frac{1}{H}\right)$ for the three vessels. The values are calculated from equation (1) with $\alpha/f^2 = 21 \times 10^{-15}$ m.$^{-1}$ sec.^{2}. They agree quite well with the measured values, within the accuracy of the measurements (~ 3 per cent). It is clear that even in the small vessel of volume 1,200 c.c., the agreement is good enough to get results for the coefficient of water.

It seems likely that the condition of the inside of the walls is important (roughness, etc.). However, there is a simple method of getting quite reproducible results. The aluminium vessels (the same as are used for household purposes) were boiled with water, if they were new, and rubbed with a piece of cloth with water and alcohol before each measurement.

Air bubbles can give difficulties. That is why boiled distilled water was used for the measurements.

A full report will appear in *Applied Scientific Research*. The apparatus has already been described in the same periodical[6].

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EXPLOSIBILITY OF AMMONIUM NITRATE

IT has long been known that ammonium nitrate can be made to explode in certain circumstances, and since the catastrophe at Oppau in 1921, it has been recognized that proper precautions should be taken. Nevertheless, there have recently been two cases, at Texas City and Brest respectively, in which ships loaded with ammonium nitrate of American manufacture have caught fire and eventually exploded with violence. At Oppau the catastrophe was ascribed to the fact that charges of explosive were used to break up the mass, which had set hard; but in the recent cases the explosions were evidently due to heat alone. As ammonium nitrate is being used on a very large scale as a fertilizer, the British

Government appointed a working party under the chairmanship of the chief inspector of explosives to investigate the matter experimentally, and a report* has now been issued. The experimental work was carried out mostly by the officers of the chief superintendent of armament research; but officers of other departments also collaborated.

Ammonium nitrate is liable to cake into a hard mass soon after manufacture; so as to keep it in a free-running condition the American product is mixed with about 1 per cent of a hydrocarbon resembling 'Vaseline' and 5 per cent of kaolin. It is packed in 100-lb. paper bags of six-ply, two of which are coated with an asphaltic composition. On the other hand, the British material for agriculture is a practically pure synthetic product (ammonium nitrate 99·8 per cent; water about 0·15 per cent). It is packed in steel drums containing 4 cwt. each.

Laboratory experiments showed that a mixture of the composition of the American product ignites more readily than pure ammonium nitrate. This was confirmed by field trials in which the two products were heated under the same conditions in artillery shells. Not only did the American material decompose more quickly and at a lower temperature than the British, but also it was liable to explode violently, whereas the British product either did not explode at all, or only did so mildly. When heated in steel tubes 2 ft. long by 0·45 in. in diameter by 0·08 in. thick, the British product burst the tube only at the end where it was actually heated, whereas that from America burst it from end to end, showing that explosion had spread to the unheated portion.

Trials on a larger scale were then carried out at the island of Dune in Heligoland Bay with British ammonium nitrate. Seventy tons of it were stacked in drums in an underground bunker of reinforced concrete, and a fire was lit of some fifteen tons of a mixture of wood and ammonium nitrate. There was no explosion, although there was evidence that the interior of the bunker had been raised to a red heat.

Similar trials were carried out in two steel lighters (or barges). In one case the ammonium nitrate was in drums and in the other in bags. In neither case was there an explosion, although the recorded temperature in the space above the nitrate rose to 500° C., and there was evidence that part of it attained a red heat. Samples of the atmosphere in the bunker and lighters were taken during the fires by an automatic apparatus. Their analysis indicated that much of the ammonium nitrate had been decomposed by the heat into oxygen, nitrogen and oxides of nitrogen.

The trials, therefore, indicate that when pure ammonium nitrate is heated it decomposes, and the pressure developed may burst the container; but even with strong confinement explosion does not extend beyond the material actually heated. Although it cannot be stated with absolute certainty that in a large consignment stored in bulk self-confinement might not lead to a true explosion of the mass in some exceptional circumstances, the results obtained show that British ammonium nitrate under normal conditions of storage and transport is safe.

Admixture of combustible material, such as paper and wood, in pieces of visible size did not cause explosion in mass. Therefore safety does not appear to be threatened by the use of paper bags or linings of waxed paper to the steel drums, although the use of such inflammable material is open to criticism.

A small amount, such as 1 per cent, of hydrocarbon mixed intimately with ammonium nitrate alters its behaviour when strongly heated. With strong confinement the decomposition becomes explosive, and the explosion may be propagated throughout the mass. Large-scale experiments were not, however, carried out with this mixture.

ARTHUR MARSHALL

*Report on Experimental Investigations on the Safety in Storage and Transport of Ammonium Nitrate. By W. A. Bailey. 12 pp. + 11 pp. of appendixes + 16 pp. of illustrations.

VALVE PORT DESIGN OF COMPRESSION-IGNITION ENGINES

ONE limitation on the maximum power developed by an internal-combustion engine is the volumetric efficiency, which is a function of so many variables that their interrelation is unfortunately not always understood. However, in a paper read before the Institution of Mechanical Engineers and entitled "The Influence of Valve Port Design on the Volumetric Efficiency of the Compression-Ignition Engine", Mr. C. B. Dicksee succeeds in explaining clearly how these factors affect volumetric efficiency, and discusses the results of experiments carried out to compare the pressure loss in various forms of venturi and straight-sided inlet ports.

The practical results of the experiments are perhaps unexciting, confirming, as they do, what has long been known and practised. Confirmatory and quantitative evidence is, however, always useful, and one particularly valuable result is that those ports which have the best performance under steady-flow conditions are found also to show the smallest losses at full load over the highest speed range. This, of course, means that the effectiveness of a port may be determined by testing it on a simple blowing rig.

The experiments consist of three series of tests, each with some six different shapes of port, and performed under steady-flow, motoring and full-load conditions. In the first series a marked improvement in the pressure loss when using the venturi is found, provided the valve seat is of adequate diameter. The other series confirm that under practical conditions it is valve-seat diameter, only, that is of importance, passage shape having a negligible effect, since its influence is so small compared with that of other factors which arise under running conditions. Other things being equal, the venturi is preferred, as it provides much-needed space in the cylinder head for the injector.

The greatest interest of the paper lies not so much in the experiments as in the comparison of petrol-engine and Diesel breathing requirements, the description of the induction process in the latter and the clear exposition, helped by some excellent light-spring diagrams, of the various complicating factors which influence volumetric efficiency. It is refreshing to find an expert who does not lay the burden of all unexplained phenomena, which transpire during the exhaust and early induction period, on the shoulders of those convenient scapegoats, exhaust pressure waves. Particularly sound is the explanation of why the motoring volumetric efficiency should be considerably higher than full-load volumetric efficiency

at low speeds, yet fall off sometimes even below the full-load value (which remains nearly constant) at high speeds. One may perhaps complain that at one point the author is not quite precise in his explanation as to why heat transfer from a cylinder wall to a turbulent charge does not increase *pro rata* with the scrubbing velocity, and, at another, no definition is given of "conventional velocity", the abscissa of one of the curves; but these are very small details. It is a paper pleasantly written, the reading of which should throw considerable light on the hidden processes of the compression-ignition engine.

TRAINING FOR MANAGEMENT

At a recent conference at Ashorne Hill, Leamington, which was organised by the West Midlands group of the British Association for Commercial and Industrial Education, the subject of training for management was examined by means of lecture and discussion.

Introducing the first session, Sir Charles Bartlett, managing director of Vauxhall Motors, reminded the conference that management was not an end in itself but a vital weapon in a nation's struggle to maintain its existence, a struggle in which failure meant utter disaster. The first speaker, Mr. D. B. Brown, managing director of the Glacier Metal Co., analysed the process of management into three stages. First, the making of policy; secondly, the decision on applying policy; and, thirdly, the execution of policy. The manager, Mr. Brown suggested, was the executive; but in the first two stages he had no more right than the other two main interests concerned, the producer and the consumer. He should see that decisions at these stages were shared with them. Although the consumer could not be consulted directly, his wishes normally were expressed through the working of the market. The producer, the man in the works, can and should be consulted. He must feel that his opinion and individuality were respected. For the third or executive stage the manager must possess real power that comes from acting with consent.

In the discussion Sir Charles Bartlett referred to other elements in responsible leadership, among them the need to lead by example. Speaking of sharing responsibilities, he said that joint consultation was sterile unless there was some real devolution of authority. In his own company, for example, authority to deal with absenteeism had been given to a joint committee and had resulted in an absence figure of less than 1 per cent.

Introducing the second session, Sir Graham Cunningham stated that management training could at least be accelerated by systematic study. The theoretical training should include the manager's preliminary education, which might end at fifteen, eighteen or twenty-one years; some training to enable him to grasp the ideas of his time; and the acquisition of knowledge of the processes and the organisation of his particular firm. The speaker in this session, Mr. N. C. Rimmer, considered the shortcomings of many of the existing methods of theoretical training for management and pointed to two things which must be done as part of this training. First, there was the study of responsibilities and functions in the process of getting a job done; secondly, there was the study of how orders should be given, to whom, by whom, and by what method.

The speaker at the third session was Mr. John Ryan, vice-chairman of the Metal Box Co., who quoted twelve attributes which had been postulated as necessary for a business leader: physical and nervous energy; enthusiasm; alertness; imagination—including a lively curiosity and interest in new ideas; character—among other things he must be truthful, temperate, and sincere; sound judgment; courage—especially to take decisions which could not please everybody; sense of humour; the ability to listen; a knowledge of human nature, with the ability to see through other people's eyes; and finally a sense of purpose and belief in his job.

Though almost all these qualities could be developed, Mr. Ryan pointed out that some were innate, and careful selection must precede training. The training of potential managers in the works would involve close surveillance by higher management. After training in administrative work the man should be given a job of his own as soon as possible, while training in specific subjects should continue. His training should also include attendance at conferences, both national and international.

In the fourth session the speaker was Prof. T. H. Marshall, who read a paper on the "Manager and the Community". In looking at management from the outside, Prof. Marshall stated that it was not always possible to distinguish between direction and management functions; the former, dealing with policy, was more relative to the major issues. This subject was fundamental in dealing with problems of social order, distribution and property, and distinction of class. Considering the actual position of management to-day, Prof. Marshall said that two questions to be answered were whether society regarded management power as legitimate, and what the responsibilities of management were—to whom and through whom.

Turning to the nature of management responsibility, Prof. Marshall traced its four directions: to the owners, or shareholders in the business; to the State, through the Government; to the customer or consumer; and to the worker in industry. If he had to place one of these first, he would choose the consumer; his interests were generally shared by the other three, whose individual interests might conflict. There was no machinery, he pointed out, for resolving such conflicts, no set of rules to be referred to. This situation, however, was common in the older professions—medicine, for example, with the conflicts, of which there were recent examples, between its responsibilities towards its patients, the community and its own science. Such conflicts were solved by building up a code of professional ethics, to which they could be individually referred. In Prof. Marshall's view, management needed a similar professional code of ethics, though it did not need the same rigid system of controlling entry and prescribing qualifications as for the professions.

Summarizing the conference, Mr. Ronald Ogden, general secretary of the British Association for Commercial and Industrial Education, stressed the necessity to realize that, whether managers like it or not, industrial democracy had come to stay, and that they must tackle the problems involved in a realistic manner. Joint consultation was one of the ways of tackling them; but joint consultation if adopted must be introduced sincerely on the part of management, and must not be looked upon as mere 'window dressing'.

T. H. Hawkins

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Additive Effect of Streptomycin and *p*-Amino-Salicylic Acid in Experimental Tuberculous Infection

By using the cornea of the rabbit as the site of infection it has been found possible, by a method based on that described by Robson[1], to produce consistently a standard tuberculous lesion reliable enough for studying the effect of anti-tuberculous substances *in vivo*. In previous work[2], it has been shown that drugs introduced into the posterior chamber (vitreous) of the rabbit's eye diffuse into the anterior chamber (aqueous) and cornea and maintain an adequate chemotherapeutic level over a period of at least 48–72 hours. Full details of the methods and results obtained with streptomycin and the sodium salt of *p*-amino-salicylic acid will be published later.* In the meantime, following the observations of Vennesland *et al.*[3] on the *in vitro* additive and synergistic effect of streptomycin and *p*-amino-salicylic acid, the combined effect of these two drugs has been tried *in vivo* using this method.

Twelve rabbits were used; in one group of six, both eyes, and in the others the right eyes only, were infected, by intracorneal injections with approximately 300 tubercle bacilli. Following a mean incubation period of eight days, all infected eyes developed early small tuberculous lesions. The animals were then divided into three groups and treated as shown in the table.

Group	No. of rabbits	Right eye	Left eye
A	6	Streptomycin and *p*-amino-salicylic acid	Streptomycin
B	3	*p*-Amino-salicylic acid	,,
C	3	Untreated controls	,,

Treatment by intravitreous injections was started on the ninth day after inoculation; streptomycin was given in 10 mgm. doses twice weekly and *p*-amino-salicylic acid in 10 mgm. doses three times a week.

Group *C* (controls) all developed rapidly progressive tuberculous lesions. In group *B* (*p*-amino-salicylic acid), although the lesions were active and progressive, *p*-amino-salicylic acid definitely slowed the natural progress of the lesions, which were smaller than in the control group. In group *A*, after four weeks treatment, the left eyes on streptomycin alone all showed very small but active lesions, whereas the right eyes on combined therapy all appeared inactive and showed fading lesions. When therapy was stopped in group *A*, after four weeks, all the lesions in both eyes rapidly spread. Under the conditions of this experiment it was thus possible to demonstrate a striking additive effect with streptomycin and *p*-amino-salicylic acid on early tuberculous lesions, though it would be incorrect to call this a synergistic effect. Other workers[4,5] have failed to show this additive effect; but here it was striking enough to suggest, if confirmed in man, that it might add considerably to the chemotherapy of acute tuberculosis, particularly in reducing the tuberculous flora before resistance to streptomycin developed.

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March 11.

* These results have, in the meantime, been published (Gardiner, P. A., Rees, R. J. W., and Robson, J. M., *Brit. J. Pharmacol.*, **4**, 209 (1949).).

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Lactic Acid and Sweat Gland Function

Sweat collected from normal male subjects carrying out work at high temperatures and humidities was analysed for chloride, lactic acid and urea. The osmotic pressure, as estimated by the freezing point in two hundred samples, is found to be accounted for by the osmotic pressure of these three constituents added together to the extent of about 95 per cent. Sodium chloride, on the average, accounts for about 80 per cent; lactate accounts for about 11 per cent.

Changes of osmotic pressure (by freezing-point determinations) and of the three components were followed through, before, during and after acclimatization to hot conditions. The osmotic pressure of the sweat in the acclimatized subject is lower than in the unacclimatized—a result to be expected from the large contribution made by sodium chloride (the correlation coefficient with freezing point is 0·86) and therefore in line with previous findings[1].

The lactic acid concentration, which may be as high as 300 mgm. per cent in the pre-acclimatized state, settles down to about 100 mgm. per cent after ten to fifteen 3-hourly exposures (Fig. 1).

The reduction in sweat lactic acid in the acclimatized or 'trained' state suggests an analogy with

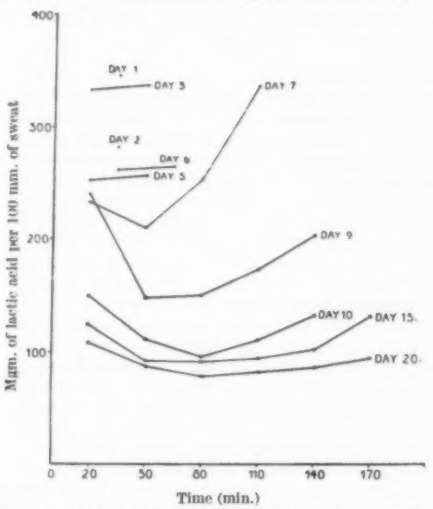

Fig. 1. Lactic acid concentration of sweat collected at half-hour intervals on successive days of exposure to 114° F. (dry bulb), and 85° F. (wet bulb), air movement being 50 ft./min.

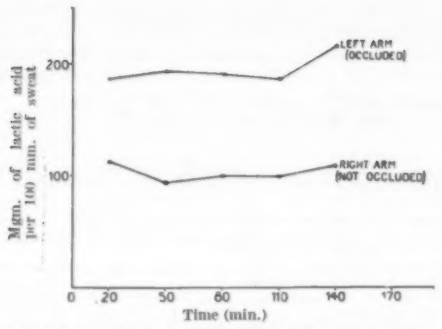

Fig. 2. Effect of ischæmia on lactic acid concentration in sweat collected from arm of acclimatized subject

muscle, and the analogy is strengthened by the finding that in an arm rendered ischæmic for 15–20 minutes in every 30 minutes sweating, over an experimental period of three hours, the lactic acid percentage is markedly increased as compared with that in the unoccluded arm (Fig. 2).

These observations, which will be reported in detail elsewhere and which are being extended, point to the importance of lactic acid production in the work of the sweat glands and in the changes in their activity with acclimatization. It may be added that glycogen is known to be present in cells of the sweat gland in considerable quantity[2], and may therefore be a precursor of the lactic acid of the sweat.

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Preparation of Bacteria for Electron Microscopy

The simplest method of preparing bacteria for observation in the electron microscope is to deposit them from suspension on to a collodion membrane. However, when developmental changes are to be followed, it is preferable to devise a means of mounting them in a state as near as possible to their normal mode of growth. We have previously described one such method[1] in which a collodion solution is poured over the growth medium and allowed to dry. When floated off in water, the resulting film carries with it the majority of bacteria. A similar method has been described by Hillier and Baker[2].

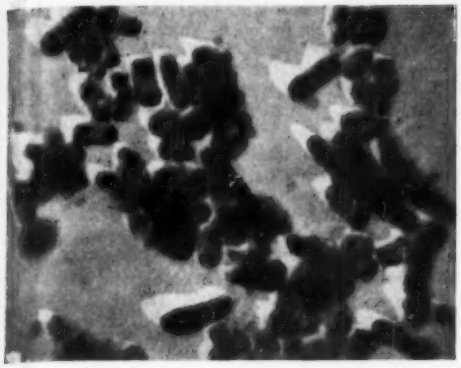
These methods, however, are open to the objection that they expose the organism to the solvent action of amyl acetate or other solvent employed for collodion, which might give rise to artefacts. The pouring of the solution across the surface of the medium may also sweep before it any organisms, or products of metabolism, which are not firmly embedded in it, with the result that important evidence of the developmental process is lost. Methods have now been devised for growing organisms directly on collodion-covered specimen grids, placed in firm contact with solid media or floated on the surface of a fluid medium, which are then transferred directly to the electron microscope, after fixation and sterilization. A minimum of interference with natural conditions of growth is thereby incurred.

The metal specimen grids are covered with a collodion film in the usual way, and preferably sterilized with ultra-violet light or in an oven. They are placed on the growth medium, and each grid is inoculated in the usual way with a minute droplet of a suspension containing the organism to be investigated. After the appropriate intervals of time, grids are removed in turn, fixed by exposure to osmium tetroxide vapour, and sterilized by formalin vapour or in an oven. If disturbing quantities of the medium remain adhering to the grid, it may be floated off on distilled water for a short time after removal from the medium. Alternatively, good results on fluid media have been obtained by interposing filter paper between grid and growth medium. After sterilization, the grid is dried and mounted in the specimen holder in the usual way.

The method thus allows of samples of growth being examined after any time, fixed and sterilized without disturbing their natural arrangement. In particular, it permits the examination of virulent and pathogenic strains with a minimum of risk, compared with previous methods. In consequence, it has been used to confirm the results obtained earlier with the electron microscope on the avian tubercle bacillus[1], and to extend the work to the bovine type. It is now hoped to examine also the human type. The micrographs are in good agreement with observations made on living material with the optical microscope in transmitted[3] and in reflected[4] light. The typical elongation that occurs after forty-eight hours growth is confirmed, the 'beaded' nature of the filaments being well shown in metal-shadowed preparations (Fig. 1). After several days, some of the filaments appear to break down into elementary units (Fig. 2), of about 0·3–0·8 micron in size. The smallest are round; but most are clearly dipolar and of the same nature as those in the old colonies used for the initial inoculation. From the present work it appears that the vacuoles in beaded filaments observed with the stripping method were probably artefacts produced by the solvent action of amyl acetate. A full account of this work will be published elsewhere.

The new method has been successfully employed with other organisms besides tubercle bacilli. It is

Fig. 1. Avian tubercle bacilli, showing elongation after 48 hours growth (shadowed with gold–palladium; × 7,700)



1 μ

Fig. 2. Avian tubercle bacilli, showing short bipolar rods after 3 to 5 days (shadowed with gold–palladium; × 7,350)

found to give good results whether the collodion film or the metal grid is in contact with the medium. Detailed investigation would be desirable, however, of the possible influence on growth of the grid metal. So far, copper and nickel grids have been used; it may be preferable to employ a noble metal.

The substance of this work was communicated to the Toronto Conference of the Electron Microscope Society of America, and to the Cambridge Conference of the Electron Microscopy Group of the Institute of Physics, in September 1948.

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V. E. Cosslett
Cavendish Laboratory,
Cambridge.

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Flocculation Optima in Diphtheria Toxoid–Antitoxin Systems

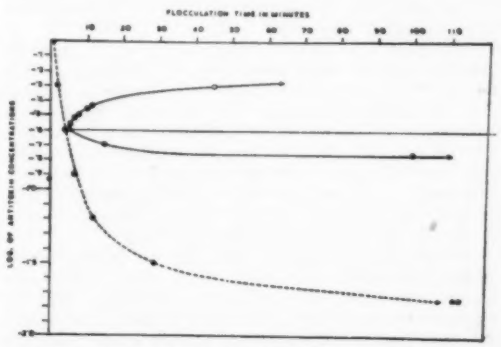
Boyd[1] suggested that the closeness of the alpha and beta optima is a property of antitoxic sera due to the narrowness of the flocculation zone in such systems ("extreme *H* type"). Boyd and Purnell[2] gave theoretical reasons why the two optima cannot coincide and suggested that the true optimum, designated epsilon, lies between them.

It seemed of interest to determine the position of the epsilon optimum using a diphtheria toxoid–antitoxin system. The toxoid used was Holt's purified diphtheria toxoid containing 2,000 Fl. units per mgm. protein nitrogen. This preparation, although representing a very high degree of purity, could still be shown by a diffusion method when undiluted (9,200 Fl. units per ml.) to contain at least two impurities giving independent flocculation zones. Impurities could not be demonstrated, however, at a level of 500 units or less. The antitoxin employed was crude horse serum.

The results were charted by Miles's method[3]. The accompanying figure shows a single Ramon titration at the level of 185 units of Holt's toxoid. On the same diagram the flocculation times of the Dean–Webb optima at different antitoxin values are shown. By definition, the epsilon optimum is the tube which contains the minimum amount of both antigen and antibody for a given flocculation time, any other combination giving longer time. The Ramon curve shown in the diagram must include the epsilon optimum since it includes theoretically all possible ratios of antigen and antibody at that level. It is also obvious, of course, that the point on the curve nearest to the ordinate represents the Ramon optimum. If alpha and beta optima coincide, the two curves can touch at one point only. Moreover, for the flocculation time at that point the product of antigen and antibody concentrations is the lowest possible, since a shorter flocculation time can be obtained only by increasing the amounts of either reagent. Thus the point must be, by definition, the epsilon optimum as well.

It will be noticed that the Ramon curve is grossly asymmetrical about a horizontal axis representing the antibody concentration at its optimum. This is due to the fact that excess of antigen inhibits more than excess of antibody. In fact, for theoretical reasons this asymmetry is necessary for the coincidence of the alpha and beta optima. With a symmetrical Ramon curve, a tangent could not touch the tip unless it were parallel to the ordinate. This is manifestly impossible for the curve representing the Dean–Webb optima, since it would imply that the flocculation time is independent of the concentration of the reagents. The asymmetrical nature of the tip of the curve is generally disregarded. Clearly a coincidence of the optima would be impossible with a symmetrical curve; on the other hand, with an asymmetrical curve coincidence is possible at any point.

The flocculative behaviour of toxin-antitoxin systems is generally regarded as an exception rather than the rule. The coincidence or closeness of alpha and beta optima in such systems is regarded solely as an outcome of the narrowness of the flocculation zone. Many of the observations believed to elucidate essential flocculative behaviour were, however, based on systems which were known to be impure (for example, serum antigens), or were eventually shown to be impure. Although some of these findings were confirmed with antigens purified by physico-chemical methods, it is by no means certain that, from the serological point of view, the required degree of purity had actually been attained. Toxins, and particularly diphtheria toxin, are capable of much



○—○—, Ramon titration (constant antigen conc. at 185 units of purified diphtheria toxoid per ml.); ●—●—, Dean–Webb optima at various antitoxin levels

greater purification than other antigens used in flocculation experiments, on account of their very sensitive indicator effect. Even the hæmocyanins used by Boyd[1] and regarded as exceptionally pure following repeated iso-electric precipitations are open to doubt, as it has been shown that at least one of them[4] contains three components of the same iso-electric point. It would not seem unreasonable, therefore, to suggest that the flocculative behaviour of toxin–antitoxin systems is the rule rather than the exception, and that therefore with a pure system the alpha and beta optima would coincide. This would appear as a more tenable premise, at any rate unless it can be disproved by the use of antigens satisfying higher degrees of purity than the ones so far investigated.

In conclusion, it is submitted that for a pure antigen–antibody system there is no evidence that more than one optimal ratio exists.

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Absorption of Immune Globulin by the Young Lamb after Ingestion of Colostrum

The absorption of immune globulin by the sucking calf has been studied in considerable detail by a number of investigators. The results obtained are probably typical of ruminants and have been confirmed to some extent for the sheep[1–3]. A further investigation of globulin absorption is reported here. It is mainly concerned with the immune globulin content of colostrum, the effect of delayed ingestion of colostrum on the lambs' serum proteins and the presence of proteins in the lambs' urine.

Lambs from ewes immunized during the latter half of pregnancy with *B. typhosus* H. antigen were either allowed to suck in the normal way at birth or were bottle-fed for varying periods and then transferred to recently lambed, unsucked ewes. Samples of colostrum, serum and urine were taken during the first ten days and at about five weeks after lambing, for examination by salting out, electrophoretic and immunological methods.

The results of these experiments, which will be published fully elsewhere, may be summarized as follows. The immune globulin of colostrum decreased rapidly during the first two or three days after lambing. It was found to be absent on the twelfth and present on the third day before lambing, in the globulin-rich secretion from the udders of ewes which afterwards yielded colostrum of high agglutinin titre. It thus appears that it can be accumulated over a relatively short period before lambing.

Absorption of immune globulin, in lambs which sucked normally, was shown by a rapid increase in serum globulin, mainly gamma-globulin, and in agglutinin, which was followed by a gradual decrease. In these animals the globulin at five weeks was still higher than at birth, but appreciably less than in the dam. The serum albumin showed a transient fall in concentration soon after birth, followed by a slight rise to approximately adult values at five weeks.

On delaying the ingestion of colostrum, absorption was found to occur up to 29 hours, but not at 48 hours or more, after birth. These results may be compared with those obtained in calves[4], which showed absorption at 24 hours but not at 42 hours.

By the time the lambs were five weeks old, there was little difference in the serum proteins of those sucking normally and those which received delayed colostrum or no colostrum at all.

A strong transient proteinuria was found in sucking lambs during the first day or two after birth. The protein present included globulin and showed an appreciable agglutinin titre. This proteinuria was correlated with the absorption of immune globulin.

Lambs were occasionally found in which the serum and urine showed traces of immune globulin before sucking. The amounts concerned were negligible compared with those obtained after sucking.

We are indebted to Dr. Howie, Rowett Research Institute, for help with the immunological part of this work.

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Local Anæsthetics and the Potassium Ion

The action of local anæsthetics on the isolated rat phrenic nerve – diaphragm at 20° C.[1] was studied with particular reference to the potassium ion. All the preparations were left for two hours before use in a bath of 70 ml. of Tyrode solution containing 0·2 per cent glucose.

Table 1. Percentage reduction of contraction of rat diaphragm produced by local anæsthetics, acting for 3 min. in a bath of 70 ml. capacity

Drug (as hydrochloride)	Dose (mg.) producing 50 per cent reduction	Dose (mg.) producing 100 per cent reduction
Procaine	20–30	50
Amylocaine	10	20
Cocaine	5–15	10–30
Amethocaine	1–3	—
Cinchocaine	1–2	—

It was first found that large doses of local anæsthetics produced neuro-muscular block *per se*. The results of contact for three minutes are recorded in Table 1; and relative activities calculated on this basis are of the same order as those found for anæsthetic action[2]. Preparations had to be primed with a few large doses of the anæsthetic before consistent responses could be obtained. Secondly, doses of amylocaine and amethocaine producing a 50 per cent inhibition were potentiated by 45 mgm. of potassium chloride given half a minute before the anæsthetic. On the other hand, 45 mgm. of potassium chloride had little or no action on corresponding doses of procaine, and this suggested a difference of action for this compound. This dose of potassium chloride

per se always increased the amplitude of the contractions.

It has already been shown that, at 20° C., recovery of the preparation after curare can be accelerated by utilizing the anti-curare property of potassium ions, provided that the curare is removed from the bath by two changes of Tyrode before the potassium chloride is added. When potassium chloride (45 mgm.) was added to the bath for 3 min. in the recovery phase (after washing out the anæsthetic), the following results were noted: with all doses of procaine, potassium chloride sometimes aided but never prevented recovery; with 10 mgm. of amylocaine or cocaine, the effect was variable, but after 20 mgm. of amylocaine or 15 mgm. or more of cocaine, potassium chloride always possessed curariform action, producing partial or complete block; with amethocaine and cinchocaine, potassium chloride always prevented recovery and produced block. In the case of the last two compounds, potassium chloride added after complete recovery again produced block. The concentration of potassium ions is known to be increased in the muscles of completely adrenalectomized rats the body temperature of which may drop to 34° C. or less. The diaphragm of such animals seemed to be more sensitive to potassium ions, and potassium chloride produced block after procaine.

Table 2. Percentage reduction of contraction of the rat diaphragm produced by amylocaine and the subsequent action of potassium

Amylocaine dose (mgm.)	Percentage reduction		Minimal dose of potassium chloride (mgm.) possessing curariform action	
	Tyrode solution	KCl-free Tyrode solution	Tyrode solution	KCl-free Tyrode solution
0	—	—	82·5	125
4	0	26	—	75
8	30	76	37·5	75
20	100	100	22·5	64

As these results suggested that potassium ions are so important, the work was repeated with Tyrode solution free from potassium chloride. Table 2 shows the percentage reduction of contraction produced by varying doses of amylocaine. In the absence of potassium ions in the Tyrode solution, the diaphragm became more sensitive to the local anæsthetic. Larger doses of potassium chloride *per se* were required to produce the curariform action than those used in normal Tyrode solution. The table shows also that the dose of potassium chloride possessing curariform action (when added in the recovery phase) had to be increased in both types of Tyrode solution when the dose of amylocaine was decreased, and *vice versa*.

Lastly, it was found that doses of *d*-tubocurarine chloride producing a 50 per cent reduction of contraction in 3 min. were potentiated by doses of 2 mgm. procaine, 3 mgm. cocaine or 0·3 mgm. amethocaine given 1½ min. before the curare. It is known that curare acts on the neuromuscular junction, and on the rat diaphragm preparation its action was antagonized by 0·5 mgm. prostigmin; on the other hand, the action of local anæsthetics was potentiated by this dose of prostigmin.

The relative activities of the five anæsthetics in the normal diaphragm preparation are of the same order as those found for anæsthetic and anti-acetylchlorine action[2,3] and for the inhibition of the peristaltic reflex of the rabbit ileum[4], although for this latter test, doses of micrograms (not milligrams) were used. In the experiments with rabbit auricle, both amethocaine and cinchocaine potentiate, instead of inhibit, the acetylcholine response, whereas cocaine is without effect. In rat diaphragm experiments, potassium ions added after washing out amethocaine or cinchocaine always produced block, whereas when added after washing out cocaine or amylocaine they had either no action or produced block. Procaine inhibits the acetylcholine action on the rabbit auricle and did not affect the normal potassium recovery in the normal rat diaphragm. On the other hand, the increase of the refractory period of the rabbit auricle produced by procaine is potentiated by potassium chloride[5]. An explanation of these facts is now being sought.

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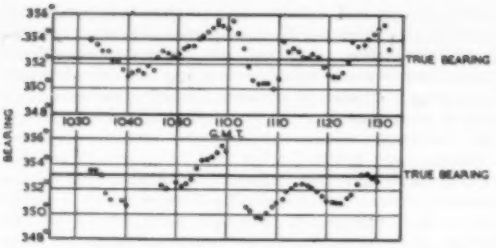
Tilts in the Ionosphere

Experience with high-frequency radio direction finding has suggested that some of the deviations from great-circle bearings observed on signals propagated by way of the ionosphere may be attributed to a tilting or wrinkling of the reflecting layer, particularly in the case of the *F*-layer. A previous communication[1] has described systematic effects due to large-scale tilts occurring around sunrise. The present note concerns deviations observed at other times, which may be attributed to a more random wrinkling of the reflecting layer. These effects are distinct from those caused by smaller-scale ionospheric irregularities which give rise to the fading and comparatively rapid fluctuations of bearing of single echoes[2]. Evidence of the existence of such tilting of the layer, with some indication of the order of magnitude of the linear dimensions involved, may be of interest, and the following preliminary results of work now in progress at the Radio Research Station, Slough, are therefore given.

Some simultaneous observations have been made with direction finders at two field stations, Sunnymeads and Winkfield, situated 10 km. apart in a roughly east–west direction, on signals emitted from a transmitter at Fraserburgh, Aberdeenshire, a distance of 700 km. to the north. At this distance, bearings taken on high-frequency signals reflected from region-*F* show fluctuations of a few degrees around the true great-circle bearing, the period of such fluctuations being usually ten to thirty minutes. The transmissions were made during the day-time and the received signal consisted of one predominant echo, namely, the first-order *F*-reflexion.

It was found that the main changes of bearing were generally very similar at both receiving stations, as illustrated in the accompanying graph, which shows the results obtained during one period of observation. The individual bearings have here been smoothed by plotting two-minute running means so as to show more clearly these slower fluctuations, which are attributable to the ionospheric tilts previously mentioned.



Bearing of Fraserburgh Transmitter, December 8, 1948; 11·03 Mc./s. Upper curve, bearings taken at Sunnymeads; lower curve, bearings taken at Winkfield

For the distance of transmission involved, bearing deviations of the magnitude shown would be produced by tilts of about 4° from the horizontal, and correspond to a lateral displacement of the reflexion point of about 20 km. Since the distance between the receivers is 10 km., the mid-points of the two trajectories will be 5 km. apart. These experiments, therefore, show that the effective ionospheric tilts observed must be substantially uniform over distances of at least this magnitude.

The direction finders used at the two sites were not identical, but both used spaced-loop aerial arrangements known to be free from polarization error. The systematic difference in bearings of 0·7° which would be expected at the two sites due to their separation is not clearly shown and is probably obscured by fixed errors, such as site errors.

The work described above was carried out as part of the programme of the Radio Research Board, and this note is published by permission of the Department of Scientific and Industrial Research.

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Amplitude Modulation of Centimetre Waves

We have found that a beam of electrons injected into a tube containing an inert gas will cause attenuation of a radio-frequency field traversing the tube, provided that the electrons have sufficient energy to ionize the gas. A device using this effect would assist the study of microwave absorption in gases. The effect has therefore been investigated with the object of producing an attenuator with electronic control.

The initial requirement was an attenuator for 1·2-cm. waves which would introduce at least 20 db. attenuation, have small insertion loss, and would have a response-time fast enough to follow a 75 kc. square wave. The preliminary investigations at 3·2 cm. have been highly successful and indicate that this type of valve may have many applications.

In the first successful type, a beam of electrons is fired axially through one of the capacitive posts of a resonant structure (loaded Q approximately 2) in a wave-guide. The other capacitive post was choke-mounted and held positive to accelerate further the electrons across the gap. A maximum attenuation of 30 db. was obtained with this type of valve. At a pressure of 2 mm. of neon, or less with argon, the response-time was adequate to reproduce quite faithfully a 75-kc. square wave, and also a 2-μ sec. pulse. In a very brief trial, quite intelligible speech modulation was obtained; but no effort has yet been made to produce faithful reproduction.

It was thought that a far greater effect could be achieved if the radio-frequency wave had a long interaction path with the discharge; moreover, the mechanism of the attenuation could be better studied with a simple co-axial device similar to a noise diode. Such a tube, coupled to a standard wave-guide by means of chokes, has been made. With this tube the maximum attenuation achieved is 50 db., while the attenuation appears, under certain conditions, to be linear with current from zero to 15 db. It has been found that the relationship between attenuation and current is independent of the incident signal-level over a range of 50 db., the maximum incident power being 100 mW.

It was noticed that, under certain conditions, what appear to be plasma oscillations are observed as a modulation of the radio-frequency signal emerging from the tube. Frequency of oscillation is of the order of 1 Mc./s., the actual frequency depending upon the nature of the gas and its pressure. The conditions for their existence appear to be very critical.

From the evidence so far available, the loss is entirely absorption, the standing wave increasing from 1·2 at zero attenuation to 1·5 at 50 db. Furthermore, it is necessary that the gas should be ionized, that is, that electrons make inelastic collisions with the gas atoms during transit from cathode to anode. At voltages below the first resonance potential there is no detectable attenuation. Work is continuing to establish the mechanism of attenuation, and to find the upper limit of response-frequency of this type of attenuator.

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Use of Radioactive Cobalt for Sphere Gap Irradiation

In many cases where sphere gaps are used for voltage measurement, and particularly where the impressed voltage wave is a short impulse, it is important to provide adequate external irradiation, or the behaviour of the test gap may be erratic and the measurements accordingly inaccurate. If a sufficient supply of initiating electrons is provided, the statistical time-lags of the test gaps are reduced, so that accurate measurement of rapidly changing voltages (lasting some microseconds or less) is possible. Irradiation of sphere gaps (*a*) by an ultra-violet lamp (for example, mercury in quartz[1–]), (*b*) by radium (usually inserted in a metal capsule and placed inside one of the spheres[1,2,4]), or (*c*) by polonium (deposited as a very thin layer on one of the electrodes[3,4]) has been successfully used by many workers.

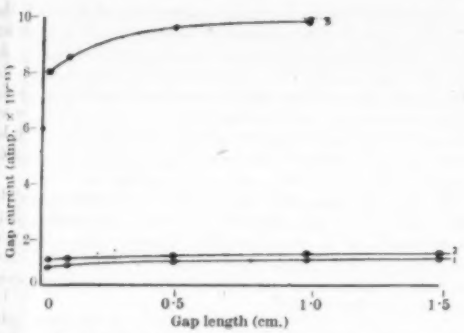

Fig. 1. Gap voltage, 100 volts; flat electrodes. Curve 1: 1 mgm. radium in brass anode (thickness of metal, 0·038 cm.); cobalt cathode. Curve 2: 1 mgm. radium in cobalt cathode (thickness of metal, 0·068 cm.); brass anode. Curve 3: Activated cobalt (cobalt-60) cathode; brass anode

Recent experiments[7] have shown that method (*a*), which has been specifically recommended[4], often gives erratic and unsatisfactory results. Method (*c*) has the defects that continued sparking wears away the active surface and that the half-life of the polonium is only 136 days. Method (*b*), using perhaps 0·5–1 mgm. radium, is widely used, and is generally satisfactory except with small sphere gaps at short spacings[4].

An alternative method, namely, the use of radioactive cobalt (cobalt-60), is now available, since the Harwell piles can provide this material in adequate amounts. It is relatively cheap, and electrodes may be machined from cobalt pieces and then irradiated in a pile so that the defect of method (*c*) is eliminated. The radioactive half-life is 5·3 years, with γ-ray energies of 1·3 and 1·1 MeV., and the β-rays also emitted (0·3 MeV. max.) should be of use in cases where the γ-rays, which liberate more electrons from the electrodes than from the air (or other gas) in the inter-electrode space of the gap, do not give sufficient ionization.

Some results, taken with flat electrodes 1·1 cm. in diameter, are given in Figs. 1 and 2. In the tests with the 1-mgm. radium capsule which was enclosed in the cathode 0·7 mm. from the surface, cobalt electrodes were also used in order to render the comparison as direct as possible. Figs. 1 and 2 show the ionization current in the gap, measured with an electrometer valve technique, plotted as a function of gap-length and voltage respectively. The particular radioactive cobalt electrode used for Figs. 1 and 2 gave an ionization current some ten times greater than that obtained with a 1-mgm. radium capsule. Covering the cobalt with 0·15 mm. of copper reduced the gap current by a factor of approximately 4, and this gives an indication of the importance of the β-rays.

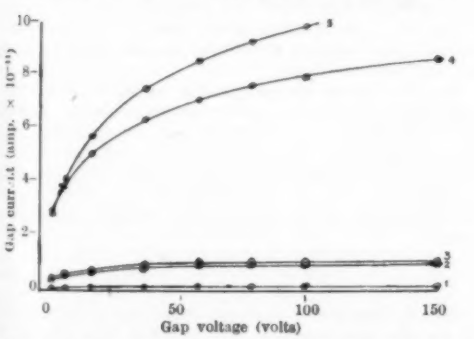

Fig. 2. Curve 1: 0·1 mgm. radium in cobalt cathode; brass anode 0·1 and 1·0 cm. gaps. Curve 2: 1·0 mgm. radium in cobalt cathode; 0·1 cm. gap. Curve 3: 1·0 mgm. radium in cobalt cathode; 1·0 cm. gap. Curve 4: Activated cobalt cathode; 0·1 cm. gap. Curve 5: Activated cobalt cathode; 1·0 cm. gap

We are greatly indebted to Prof. J. M. Meek for many valuable discussions on the work and to the authorities at the Atomic Energy Research Establishment, Harwell, for the cobalt irradiations.

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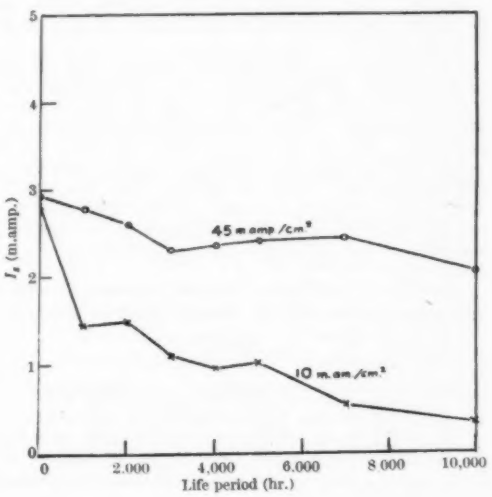
Influence of the Density of Emission on the Life of Oxide Cathodes

A detailed research carried out in these laboratories appears to prove that cathode life is not prejudiced by increasing emission densities. This result may be of importance in valve technology, and a note at this stage seems worth while.

The experiments concerned were undertaken with experimental diodes which were built with guard rings covering the cooled ends of the cathodes. Only the currents flowing to the centre anode have been referred to below. The first diodes, which have now reached 10,000 hr. of life, were operated at a uniform temperature of ≃ 1,075° K. (actual temperature). Two different current densities were drawn from the cathodes (10 or 45 m.amp./cm.² respectively). The maximum anode voltage necessary for obtaining these



densities was 15 volts, and was, therefore, sufficiently low to avoid an appreciable ionization of residual gases in the valves. The emissivity of the cathodes was checked by measuring the saturated current, I_s, at a temperature of approximately 750° K. (V_A = 10 volts).

The accompanying graph shows the saturated current as a function of life for two different batches of diodes. Each of these batches consisted of eight valves, and the mean value of all these valves has been plotted. It is seen that the decrease of the saturated current during life is certainly not increased by increasing the current density from 10 to 45 m.amp./cm.²; rather an increased current density is favourable for the life. This result was confirmed by a number of other batches which were examined in the same way.

With some further valves, not only the emission density was varied but also the temperature at which the cathodes were operated. The two temperatures used were 1,075° and 900° K. The result obtained during 3,000 hr. life is given in Table 1 (mean values for eight valves each).

Table 1

Operating temperature	1,075° K.			900° K.	
Emission density	10 m.amp./cm.²		45 m.amp./cm.²	10 m.amp./cm.²	45 m.amp./cm.²
	A	*B*			
	m.amp.	m.amp.	m.amp.	m.amp.	m.amp.
I_s at 0hr	1·17	1·14	1·19	1·00	1·35
I_s at 3000 ,,	0·88	0·09	1·36	1·07	2·37

It is seen again that a high emission density is slightly favourable, and that this effect is especially observed at the low temperature, where the valves operated with 45 m.amp./cm.² show a pronounced increase of the saturated current. Attention may be directed to the difference observed between the two batches *A* and *B* operated with 10 m.amp./cm.² at 1,075° K. These batches differed only in the composition of the nickel sleeves used for their cathodes, batch *B* having 0·4 per cent iron in the sleeves compared with 0·2 per cent iron in the sleeves of the other batches.

Finally, the emission density drawn from the cathodes was increased still further up to about 200 m.amp./cm.².

These experiments were undertaken with diodes of a different design; they had a flat cathode and two anodes with different spacings on the two sides of the cathode. The cathode–anode spacing was chosen in such a way that, with the same anode voltage of 9 volts, an average emission density of 230 m.amp./cm.² could be drawn from one side of the cathode while the density on the other side was only 10 m.amp./cm.². The influence of the emission density on life could thus be examined within the same valve.

The results obtained with these diodes at a cathode temperature of 1,075° K. during 3,000 hr. operation

Table 2

Emission density	10 m.amp./cm.²	230 m.amp./cm.²
I_s at 500 hr.	0·64 m.amp.	1·19 m.amp.
I_s ,, 1,000 ,,	0·59 ,,	0·97 ,,
I_s ,, 2,000 ,,	0·53 ,,	1·05 ,,
I_s ,, 3,000 ,,	0·44 ,,	0·78 ,,

are given in Table 2 (mean values for eight valves). The values of the saturated currents at zero time have not been given because they are not comparable, due to an increase in cathode temperature during the initial life-period which was produced by a metal deposit forming on the glass bulb of the valves. The values of Table 2 show that an increase in current density by a factor of more than 20 has no detrimental effect on the cathodes examined.

It may be concluded from these experiments that the life of oxide-cathodes is not affected, when increasing to a considerable extent the emission density drawn from the cathodes, provided the emission current is prevented from ionizing gases existing in the valve.

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Grain Size of Martensite after Treatment at Very Low Temperatures

In investigations on steels containing respectively 0·89 and 1·2 per cent of carbon and subjected to very low temperatures, questions arise concerning the intense line broadening and the grain size of martensite after different heat treatments.

The problem of grain size in particular is still unsettled[1]. The breadth of the lines has been measured by means of two methods: (i) Scherrer, half-maximum breadth, (ii) the 'integral' Laue breadth; the ferrite lines have been used as standard lines. Corrections for the alpha-doublet and 'instrumental' broadening in the observed breadths of the lines were made according to Jones's method[2]; in doubtful cases the method recently described by Stokes[3] has been applied. In order to test the reproducibility of the results, three or four independent runs were made for each reflexion on each film, and usually about eight films were taken to obtain a final average value. From the breadth of the line, the average size of the crystal grains has been estimated using the formula

$$\beta = \frac{K\lambda}{\varepsilon \cos\theta},$$

λ being the wave-length of the monochromatic X-rays, θ the Bragg angle, K a constant, β the measure of the angular breadth of the line at the half-peak value, ε the 'apparent' crystal dimension normal to the diffraction plane.

In the present investigations, neither of the products $\beta\cos\theta$ nor $\beta\cot\theta$ shows constancy; $\beta\cos\theta$ increases and $\beta\cot\theta$ decreases fairly regularly from M_4 to M_8; this being the case, it cannot be said that the broadening is exclusively due only to small particle sizes, or to the strain alone. If both are present together, an approximate treatment suggests that

$$\beta\cos\theta = A\sin\theta + B\lambda,$$

where A depends on the root mean square strain and B on the reciprocal of the particle size (A. J. C. Wilson, private communication). If $\beta\cos\theta$ is plotted against $\sin\theta$, a nearly straight line which does not pass through the origin will be obtained in all cases.

Thus the influence of the strain on the broadening and the influence of the small grain size have been confirmed. The lines become slightly broader after low-temperature treatment, and this may indicate either slightly smaller crystals, or greater strain, or both.

The separation of these two effects is extremely difficult and requires extensive studies with several X-ray wave-lengths.

The numerical values in angstroms for the 'apparent' grain size of martensite are as follow :

Carbon content %	*a*	*b*	*c*
0·89	72·65	69·01	67·26
1·20	76·71	76·27	73·65

Samples were quenched in brine (*a*), followed by immersion in liquid nitrogen (*b*), and, finally, in liquid helium (*c*).

The influence of the small grain size of martensite cannot be neglected, the more so as it is only sizes less than 100 A. which are necessary to produce broadening sufficient for reliable measurements[4]. The main factor causing the broadening of the lines is, according to the usual view, the internal stress. The grain size of austenite after different heat treatments has been estimated in the present work, and the conclusion is that the grain sizes of martensite are not greatly different from those of the parent austenite. The same opinion has been expressed by Heindlhofer and Bain[5]. A full report on the subject will be published elsewhere.

I wish to thank Prof. C. W. Dannatt for the provision of laboratory facilities and his constant interest in the work.

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March 15.

[1] Epstein, S., "The Alloys of Iron and Carbon", **1**, "Constitution", 201 (New York : McGraw-Hill Book Co., 1936).
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[3] Stokes, A. R., *Proc. Phys. Soc.*, **61**, 382 (1948).
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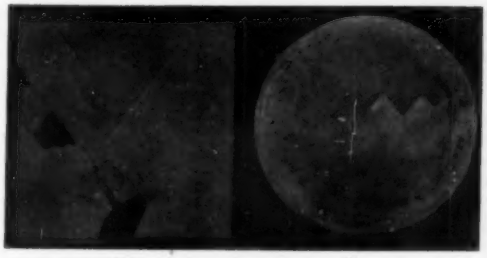
A Method of Determination of the z-Axis on *x*-Cut Quartz Plates and Directions of Easy Breaking of Quartz Plates

ACCORDING to Voigt[1], the quartz crystal cracks along the rhombohedral surfaces (*r*) when suddenly cooled from high temperatures. Seidl[2] reported for a quartz plate of *x*-cut a case in which the thermal cracking showed a zigzag path made up of segments nearly parallel to these surfaces. Schubnikow[3] obtained cracks in two directions by applying pressures on an *x*-cut quartz plate. These cracks are stated to be parallel to the rhombohedral surfaces, although his photograph seems to indicate that the angles between the cracks are smaller than the rhombohedral angle (84° 12′). Hirata[4] obtained cracks like networks on a quartz plate of *x*-cut and on natural prismatic surfaces by electric discharges in water, the direction of the spark being parallel to the surface of the plate.

It is well known that the piezo-electric quartz plates used as ultrasonic transmitters often show sudden breakings mainly caused by electric discharges in the surrounding medium. By examining many such plates, I noticed that many of the boundaries run along straight paths rather than curved ones, and that the straight cracked surfaces are sometimes as smooth as good cleavages of other crystals ; also the zigzag cracks are often observed, and the zig zags are greater for thicker plates and smaller for thinner ones (cf. accompanying photograph).



(*a*) (*b*)

Quartz plates broken by ultrasonic vibrations. (*a*) Square plate of 50 mm. × 50 mm. × 2 mm., right-handed quartz ; (*b*) circular plate 50 mm. in diameter and 6 mm. thick, left-handed quartz. Both plates show the negative sides of the *x*-surfaces, with the *z*-axes directed vertically

The directions of straight or zigzag cracks were determined for six square plates and ten circular ones. They were all *x*-cut plates of thickness between 1 mm. and 6 mm. The plates were etched by hydrofluoric acid, and the distinction between the right- and the left-handedness of the crystal and between the positive and negative senses of the *x*-axis were made by observing the etch-figures with a microscope.

A rough estimation of the direction of the *z*-axis is also made in this way. But the exact determination of the *z*-axis was performed by the following method. Place an etched quartz plate on a paper, on which a straight line or preferably crossed lines are drawn ; the lines will appear generally as double or multiple lines, but the spacings are usually not equal for lines mutually perpendicular. When the negative *x*-surface points towards the observer, the image splits into directions perpendicular to the *z*-axis, the separation being usually about 2·3 mm. for plates of thickness 6 mm. This phenomenon is explained as the geometrical double-image formation as in the case of Fresnel's biprism, the small etched-out surfaces of various dimensions, but with regular orientations, acting as refracting surfaces.

The orientation of the etched-out surfaces were calculated from the directions and the amounts of splittings of the image. The facets etched out on negative *x*-surfaces proved to be usually *m*-faces ($(10\bar{1}0)$ and $(1\bar{1}00)$) and sometimes $(8\bar{1}\bar{7}0)$ and $(8\bar{7}\bar{1}0)$ surfaces. The same phenomenon observed through an etched quartz plate with its positive *x*-surface pointing towards the observer was more complicated, and I had to attribute it to three pairs of splittings by three pairs of small refracting surfaces : (*a*) the *m*-surfaces (or sometimes $(8\bar{1}\bar{7}0)$ and $(8\bar{7}\bar{1}0)$ surfaces), (*b*) the *r*-surfaces ($(10\bar{1}1)$ and $(1\bar{1}01)$), and (*c*) perhaps the $(32\bar{1}1)$ and $(3\bar{1}\bar{2}1)$ surfaces, although the third pair was not directly observable in microscopic etch-figures.

For thick plates the directions of the *z*-axis were also determined by using optical double refraction of the light passed through the edges of the plate.

The directions of straight or zigzag cracks determined in these ways proved to be nearly constant

and included in the mean angles of $\gamma = 73{\cdot}8°$ (or $\alpha + \beta = 74{\cdot}7°$) between them, making angles of $\alpha = 38{\cdot}2°$ and $\beta = 36{\cdot}5°$ with the z-axis respectively. The cracks with angles α were nearly parallel to the r-surface and the cracks of angle β were nearly parallel to the r'-surface. The observed angles showed fluctuations of maximum $\pm 2{\cdot}5°$ with a few exceptions, and this fluctuation was slightly larger than experimental errors.

Thus the directions of easy breaking of x-cut quartz plates, at least in the case of breaking by ultrasonic vibrations, are not the two rhombohedral surfaces, which make angles of 95° 48′ to each other, and which are asymmetrically placed with respect to the z-axis with angles of 38° 13′ on the side of α and 57° 35′ on the side of β; but that they are nearly parallel to two sets of surfaces, one being the rhombohedral face, which makes an angle of 38° 13′ with the z-axis and which is perpendicular to the surface of the x-cut plate, and the other being parallel to the r'-face, which is symmetrically placed to the r-surface with respect to the z-axis.

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[1] Voigt, "Kristallphysik", 701 (1910).
[2] Seidl, F., *Naturwiss.*, **17**, 81 (1929).
[3] Schubnikow, A., *Z. Kristallogr.*, **74**, 103 (1930).
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Flat-Fielded Reflecting Micro-Objectives

'Solid' reflecting objectives can be made flat-fielded without introduction of chromatic focal errors. The two long working-distance types resulting, (*a*) dry and (*b*) immersion respectively, compare not unfavourably with the type developed by Dr. C. R. Burch[1], which itself can have a flat field if used with a normal-incidence oil component of suitable small radius. Examples having approximately the same overall size, obstruction ratio (1 : 7), and astigmatism equal to and two-thirds respectively of the latter type are given below. They have the advantage of retaining constant alignment of the two surfaces, of which only one is non-spherical.

Type *a* (Fig. 1) with, for example, N.A. 0·6, working distance 1 cm. and magnification 48 for $R = 0{\cdot}0318$ cm., has an annulled field curve of $1{\cdot}046\ h^2$ at off-axis height 'h'. Partial field flattening accompanies corrections for forming an image at finite tube-length, full compensation being arranged for any n, by proper choice of the normal incidence entry surface.

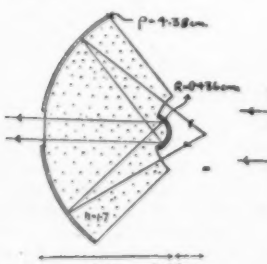

Fig. 1

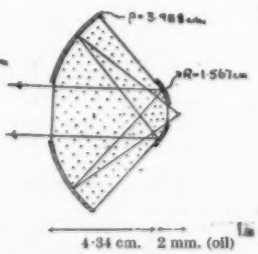

Fig. 2

As a solid immersion objective, type *b* (Fig. 2) has properties indicating a wide sphere of usefulness; for example, N.A. 0·9, working distance > 2 mm. (oil); field curve (annulled) $0{\cdot}1906\ h^2$. Hence, given n, proper choice of R [2] and tube-length (that is, magnification), produces a flat field, a low magnification example being for $n = 1{\cdot}5$ and $R = 1{\cdot}396$, magnification = 10.

Given homogeneous fused quartz, spectral limits from 1,800 to 40,000 A. are within the range of these types. Indeed, with advance in commercial production of aspherical surfaces, the properties of these achromatic flat-fielded semi-aplanats augur well for their competing eventually with conventional types over a wide range.

A fuller account of these types and their construction will be reported later.

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Rapid Calculation of Standard Deviations

In statistical work, one of the commonest arithmetical operations is finding the sum of squares of deviations of a set of numbers from their mean, zero, or some other fixed point, often followed by extraction of the square root of the result. When a machine is not available, the calculations are very tedious and liable to error. I have, therefore, tried out a simple geometrical method, illustrated in Fig. 1.

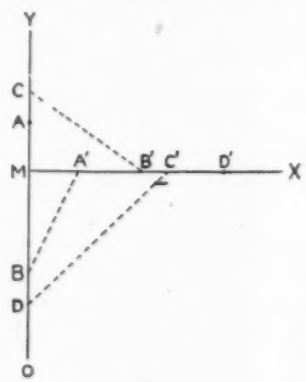

Fig. 1

On a sheet of squared paper a vertical axis OY is marked with a convenient scale to contain all the points A, B, C, D, . . . corresponding to the numbers in the original data. The horizontal axis MX is drawn through the point M representing the mean or other value from which deviations are to be measured. Let AM be a, BM be b, and so on. With a pair of dividers mark off MA' equal to MA. Keeping one leg of the dividers at A', place the other at B. The span $A'B$ will be equal to $(a^2 + b^2)^{1/2}$. Transfer this to MB', keep one leg at B', and put the other at C. The dividers now register $(a^2 + b^2 + c^2)^{1/2}$. Transfer to MC', pivot at C' and span $C'D$; and so on, until all the data are included. The final setting will be the square root of the sum of the squared

deviations. If the total becomes too large for the span of the dividers or the size of the graph paper, a sub-total may be stored by pricking it along a ruling of the paper, and a fresh start made. The sub-totals are afterwards combined, if necessary after a suitable change in scale.

This procedure takes less time than use of a calculating machine. Accuracy is surprisingly high. Several people have used the method, and the result scarcely ever differs by more than 2 per cent from the exact figure, and is usually within 1 per cent. This is good enough for most practical purposes. It is advisable to check the first few efforts against the exact answers, since some people have a tendency to get results consistently too low or too high, due to placing the point of the dividers slightly inside or outside the vertical axis OY. This fault, if detected early, is easily corrected. It is also important to get the first perforation accurately at M.

To get the estimated population standard deviation, one divides the answer by $(n-1)^{1/2}$, and again by $n^{1/2}$ to get the standard error of the mean. This can be done on a slide rule. In quality-control work, however, an even quicker procedure is possible. For samples of 5, $(n-1)^{1/2}$ is 2, and for samples of 10 it is 3. Using these divisors, the geometrical method of estimating standard deviation is even easier than range multiplied by a factor. Even this small amount of arithmetic can be avoided; for by a suitable choice of scales, the final setting of the dividers can be pricked directly on to the control chart.

Correlations and regressions can also be worked out. Use is made of the identities

$$2\Sigma XY = \Sigma X^2 + \Sigma Y^2 - \Sigma(X-Y)^2 \quad (1)$$

$$\text{or } -2\Sigma XY = \Sigma X^2 + \Sigma Y^2 - \Sigma(X+Y)^2, \quad (2)$$

where X and Y denote the correlated quantities, measured from their respective means. Equation (1) is used when the correlation is expected to be positive, and (2) when a negative value is anticipated. Use the geometrical method to find the square roots of the three terms on the right of the equation, and call the results x, y and z. Lay off $OX = x$, $OY = y$ and $OZ = z$, as shown in Fig. 2*a*. With XY as radius and Z as centre, find A. Then OA is the square root of twice the sum of products. Fig. 2*b* shows the procedure if OZ is longer than XY. Transfer XY to OB. With B as centre and OZ as radius, find C. Then OC is the square root of twice the sum of products, but the sign of the correlation must be reversed—negative if equation (1) is used, and positive for equation (2). The rest of the calculation of correlation or regression coefficients is easily done on the slide rule.

With dividers, graph paper and slide rule, complex computations like biological assays and elaborate analyses of variance and covariance can be very quickly performed, with a degree of accuracy sufficient for most practical purposes. Where mechanical equipment is available, geometrical methods are still very convenient for rapid checking. They are also extremely useful in teaching, enabling students to work out examples at home.

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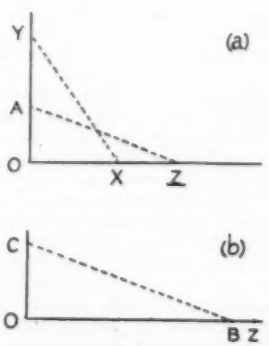
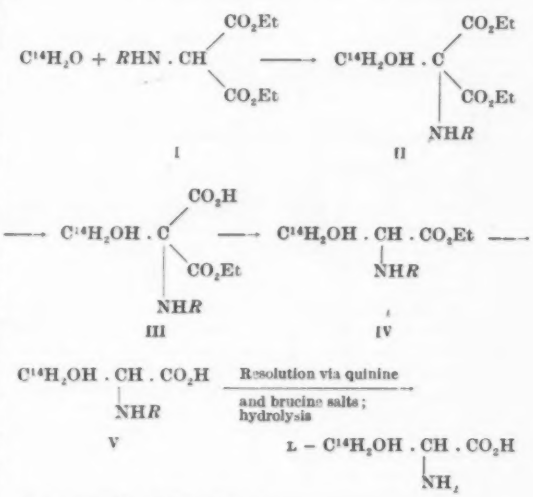


Fig. 2

Synthesis of L-Serine Labelled with Carbon-14 in the Hydroxymethyl Group

β-Carbon-14-L-serine has been prepared from carbon-14 formaldehyde by a modification of King's synthesis of DL-serine[1], using ethyl *p*-nitrobenzamidomalonate (I) instead of ethyl acetamidomalonate in order to facilitate optical resolution.

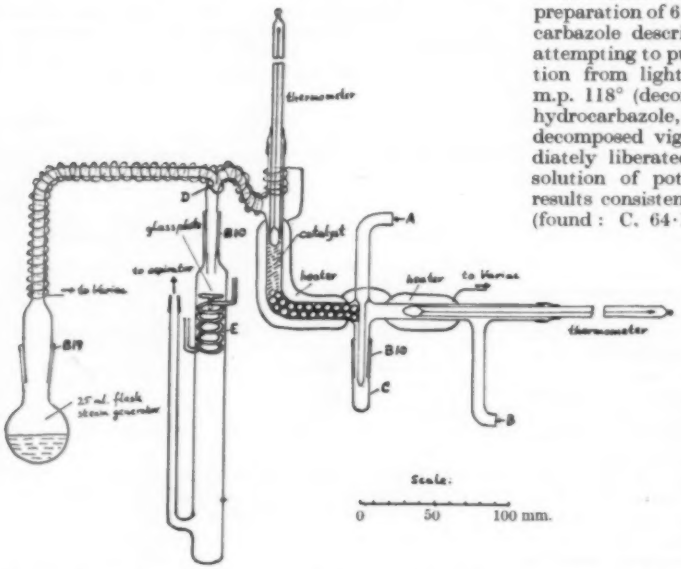


(R = *p*—$NO_2 . C_6H_4 . CO$—)

Preliminary work showed that condensation of formaldehyde with ethyl *p*-nitrobenzamidomalonate (I), m.p. 136° (found: C, 52·0; H, 4·8; N, 8·6; $C_{14}H_{16}O_7N_2$ requires C, 51·9; H, 5·0; N, 8·6 per cent), prepared by acylation of ethyl aminomalonate in pyridine at 0°, could be effected in 94 per cent yield in 50 per cent aqueous pyridine at room temperature. The product (II), m.p. 100–102° (found: C, 50·9; H, 5·4; N, 8·0; $C_{15}H_{18}O_8N_2$ requires C, 50·9; H, 5·1; N, 7·9 per cent), was hydrolysed at room temperature with one equivalent of N sodium hydroxide in aqueous ethanol. After evaporation of the ethanol, one equivalent of N hydrochloric acid was added, when the half-ester (III) lost carbon dioxide spontaneously, the reaction being completed by warming. Further hydrolysis of the intermediate (IV) with one equivalent of N sodium hydroxide in

aqueous ethanol and acidification of the concentrated solution with excess hydrochloric acid yielded slightly impure *p*-nitrobenzoylserine (V), m.p. 191–193°, in 68 per cent overall yield from formaldehyde.

Carbon-14 formaldehyde was prepared from carbon-14 methanol by catalytic oxidation with air at 350–400°, using a molybdenum (90 per cent) – iron (10 per cent) oxide catalyst[2] in the apparatus shown in the accompanying diagram, which was made of 'Pyrex' tubing. Dry air free from carbon dioxide was admitted through the inlet *A* at a rate of 120–150 ml./min. The vessel *C*, containing methanol (200–400 mgm.), was immersed in a bath kept at 20°. At this temperature vaporization of the methanol occurred at the required rate, giving a methanol : air ratio of about 1 : 10 to 1 : 15. When desired, additional air or oxygen could be admitted at *B*. Thorough mixing and heating was accomplished by passing the gases through a length of heated tube packed with glass beads (4 mm. diameter). The catalyst (1 gm.), as moderately coarse lumps, was packed into the vertical part of the heated tube. Condensation of polymer was prevented by warming the exit vapours and by injection of steam at *D*. After cooling by the internal spiral water condenser *E*, the aqueous solution of formaldehyde was frozen in the liquid-air trap.



In trial experiments, yields of 75–80 per cent were obtained, the formaldehyde being estimated by titration with iodine in alkaline solution[3] and as the dimedon derivative. In an actual run, carbon-14 methanol (32·5 mgm., approx. 1 millicurie) was diluted with 378·9 mgm. inactive methanol and oxidized to formaldehyde (yield : 294 mgm., 76 per cent by titration, 71 per cent by estimation as dimedon derivative ; radioactivity recovered : 0·545 mC.). The above formaldehyde solution (9·6 ml., 524 μC.) was condensed with a slight excess of ethyl *p*-nitrobenzamidomalonate (3·25 gm.) in 30 ml. 50 per cent aqueous pyridine, giving 1·80 gm. crude *p*-nitrobenzoylserine (269 μC., 51·5 per cent). A portion of this material was diluted with *p*-nitrobenzoyl-DL-serine[4], giving 6·15 gm. almost pure carbon-14 *p*-nitrobenzoyl-DL-serine (217 μC., specific activity : 8·96 μC./mM.). This material was resolved through the quinine and brucine salts and hydrolysed with 3 *N* hydrochloric acid, yielding L-serine having a specific activity of 8·53 μC./mM.

Full details will be published elsewhere. I wish to thank Dr. A. Neuberger for his interest in this work, and Dr. G. Popják for helpful advice with the radioactivity measurements.

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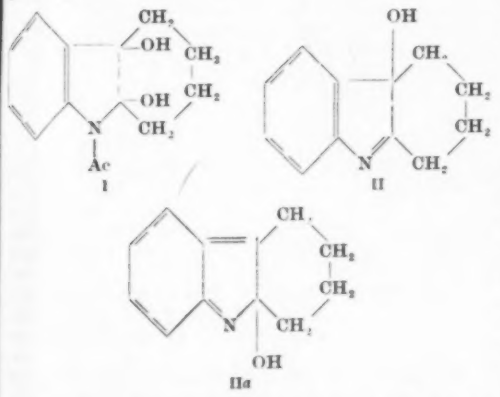
[1] King, J. A., *J. Amer Chem. Soc.*, **69**, 2738 (1947).
[2] Amer. Patent No. 1,913,405.
[3] Fresenius, W., and Grünhut, L., *Z. anal. Chem.*, **44**, 13 (1905).
[4] Fischer, E., and Jacobs, W. A., *Ber.*, **39**, 2942 (1906).

Tetrahydrocarbazole Peroxides

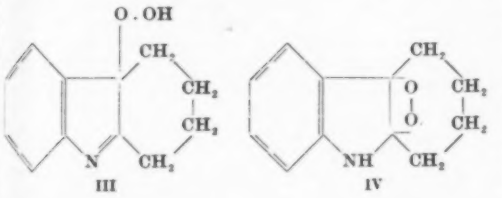
We have recently had occasion to repeat the preparation of 6 : 7-dimethoxy-1 : 2 : 3 : 4-tetrahydrocarbazole described by Hughes and Lions[1] and, in attempting to purify the crude product by crystallization from light petroleum, obtained a compound, m.p. 118° (decomp.), in place of the expected tetrahydrocarbazole, m.p. 98°. The new compound, which decomposed vigorously at its melting point, immediately liberated iodine from an acidified aqueous solution of potassium iodide and gave analytical results consistent with its formulation as a peroxide (found : C, 64·1, 64·0 ; H, 6·6, 6·3 ; N, 5·8, 6·0. $C_{14}H_{17}O_4N$ requires : C, 63·9 ; H, 6·5 ; N, 5·3 per cent).

From further experiments it now appears that peroxide formation is a general property of the tetrahydrocarbazole series. Thus, 6 : 7-methylenedioxy-1 : 2 : 3 : 4-tetrahydrocarbazole affords a peroxide, m.p. 123° (decomp.), and 1 : 2 : 3 : 4-tetrahydrocarbazole itself readily combines with atmospheric oxygen to give a similar product which crystallizes in almost colourless tablets, m.p. 123–124° (decomp.) (found : C, 70·7 ; H, 6·7 ; N, 7·0. $C_{12}H_{13}O_2N$ requires : C, 70·9 ; H, 6·4 ; N, 6·9 per cent). In contrast to the parent compounds which, as is well known, are virtually non-basic, the peroxides dissolve easily in dilute aqueous mineral acids. The acid solutions, however, are unstable and rapidly deposit coloured amorphous products. When shaken with dilute aqueous sodium hydroxide, the peroxide from tetrahydrocarbazole slowly dissolves, forming a pale yellow solution. Careful addition of dilute hydrochloric acid to the latter solution precipitates an initially sticky solid which re-dissolves in excess acid. This precipitate appears to be a mixture of unchanged peroxide and another substance which is the main product when the original alkaline solution is kept for some time before being neutralized. With hot alkali the peroxide is rapidly decomposed, the reaction giving rise to two products, a colourless amphoteric substance of high melting point and a neutral compound which crystallizes from light petroleum in lemon-yellow needles or prisms, m.p. 79°.

The latter product, which yields an acetate forming colourless prisms from light petroleum, m.p. 113–114°, is also obtained together with other substances by reduction of the peroxide with iron powder and acetic acid. From its properties, it seemed probable that the yellow compound, m.p. 79°, was identical with the "hydroxytetrahydrocarbazolenine" (II or IIa), m.p. 79° (acetate, m.p. 113°) of Perkin and Plant[2]. Repetition of the latter authors' preparation, namely, treatment of 9-acetyl-10 : 11-dihydroxyhexahydrocarbazole (I) with hot aqueous alcoholic potassium hydroxide, has given a product identical with the compound, m.p. 79°, obtained from the peroxide.



On the basis of these preliminary results, it is not yet possible to assign definite structures to the tetrahydrocarbazole peroxides; but we are adopting, as a working hypothesis, the expression (III) for tetrahydrocarbazole peroxide, with structure (IV) as a less likely alternative. The first of these accounts satisfactorily for the observed basicity and weak acidity, since it is both a hydroperoxide and a tetrahydrocarbazolenine. The cyclic structure (IV) might explain the basic properties of the peroxides, but a compound having this formula would only become acidic as the result of a rearrangement to type (III).



A detailed examination of the properties and reactions of this new group of organic peroxides is in progress, and the results of the investigations will be published elsewhere in due course.

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[1] Hughes and Lions, *J. Proc. Roy. Soc. N.S. Wales*, **71**, 428 (1938).
[2] Perkin and Plant, *J. Chem. Soc.*, **123**, 689 (1923).

Reactivity and Specificity of Precipitates Obtained by Treating Alcoholic Extracts of Beef Heart with Solutions of Various Inorganic Salts

Experiments conducted with the purpose of excluding cholesterol as an essential constituent of antigens used in serological tests for syphilis have led to some interesting results.

The preliminary work in this series of experiments was performed with precipitates obtained by treating alcoholic extracts of beef heart powder with sodium chloride solutions varying in concentration from 0·85 per cent to saturated. Precipitates thus formed were rendered free from excess sodium chloride by adequate washing, and resuspended in normal saline. When tested with known negative and positive syphilitic sera, specific results were obtained; but under the conditions of the test, reactions with positive sera took place rather slowly after the mixture had been shaken for five minutes and afterwards incubated at 37° C. Centrifuging the well-shaken mixtures accelerated the reactions, and it was noted that the precipitates obtained with the higher concentration of salt solutions were far more reactive than those obtained with the weaker solutions.

Efforts were then made to obtain precipitates which would react more readily. A 20 per cent barium chloride solution was used as the precipitant in subsequent experiments with alcoholic extracts of beef heart. After removal of excess barium chloride by adequate washing, the precipitate was suspended in distilled water and tested with known positive and negative sera. With strongly reacting sera the smooth suspensions showed macroscopic precipitation; but the mixtures required centrifuging before the reaction could be discerned. Weakly positive sera failed to react; but there is a possibility that, by suitable adjustment of the antigen and the antigen/antibody ratio, a more sensitive test might be evolved using the barium precipitate. The problem is being more thoroughly investigated.

The fraction precipitated from the alcoholic extracts of beef heart was removed and the clear supernatant fluid treated with 50 per cent cadmium chloride. Precipitates thus obtained were thoroughly washed to remove excess of free cadmium chloride and then suspended in a phosphate buffer solution of *p*H 6·4 to form a colloidal solution. When positive and negative sera were tested with these suspensions, accurate specific results were obtained. As yet, this test has been performed using only one proportion of antigen to serum. Positive sera react powerfully immediately after five minutes shaking of the antigen/serum mixtures on a mechanical shaker. 939 sera submitted for routine serological examination were tested by this method, and the parallel results detailed here (see table) indicate the apparent specific reactivity of the cadmium chloride precipitate *in vitro*.

Negative to Modified Ide Screen and cadmium chloride tests				551
Positive	"	"	"	263
Negative	"	" positive or doubtful	"	82
Positive or doubtful	"	negative	"	43
			Total	939

It is interesting to note that barium chloride is used to precipitate cardiolipin from an alcoholic solution of beef heart powder, whereupon crude lecithin is believed to remain in the supernatant fluid.

Treatment of the latter with cadmium chloride yields the cadmium chloride complex of crude lecithin. Presumably, then, the above reactions have taken place in the absence of both cardiolipin and cholesterol. However, the possibility of there still being a small amount of cardiolipin present has been considered, and repeat experiments on similar lines are in progress using both partially purified and purified lecithin solutions.

Other precipitates from alcoholic extracts of beef heart which have been tested are those produced by treatment of the extracts with 1 per cent sodium gold chloride and 5 per cent silver nitrate solutions respectively.

The precipitate formed with the sodium gold chloride solution is bright orange-yellow. Suspension of this material in a phosphate buffer solution of *p*H 6·4 yields a yellowish colloidal solution which when tested with syphilitic serum gives only a feeble reaction, although normal sera are clearly negative. However, on exposure of the colloidal solution to light for fifteen minutes, a ruby red coloration develops similar to that noted in Lange's colloidal gold solution. This 'colloidal gold' suspension is strongly active with syphilitic sera, giving a bronze precipitate in an almost colourless fluid; but an adjustment of the *p*H is considered necessary for the production of more highly specific results. It is to be noted that the ruby red colour fails to develop when the solution is stored in the dark either at room temperature or in the refrigerator.

The silver nitrate precipitates formed with alcoholic extracts assume a brown colloidal state when suitably suspended. These react strongly with syphilitic sera, the positive precipitate being dark brown, while a negative reaction is shown by a light-brownish opalescent solution.

An adequate number of tests have not so far been made to determine the actual specificity and sensitivity of the reactions obtained with these precipitates.

Further details of the work in progress will be given at a later date, together with the results obtained with precipitates formed by treatment of both crude and purified extracts of the apparently active fractions of beef heart muscle with the salts of calcium, uranium, lead and mercury. Comparative readings will be made with diagnostic antigens such as are used in the Eagle flocculation, Kahn precipitation and Kolmer complement-fixation procedures.

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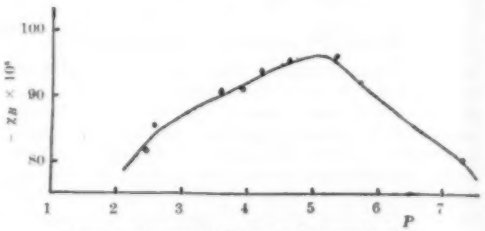
Magnetic Susceptibilities of Polyindene Fractions

Farquharson and Ady[1] examined the polymerization of 2,3-dimethylbutadiene, and Bhatnagar, Kapur and Kaur[2] that of styrene by measuring the magnetic susceptibilities. But there are no determinations comparing the susceptibilities at different degrees of polymerization.

This has been done for polyindene fractions by the cylinder method, resulting in a kinetic investigation[3]. The field strength of the magnet used was calibrated by chloroform ($\chi = -0{\cdot}61 \times 10^{-6}$) and amounted to 9,460 oersteds with poles 7·1 mm. apart and at 7 amp. (χ_B is the susceptibility of a basic molecule).

Fraction	Degree of polymerization	$-\chi_B \times 10^6$
I	2·45	81·7
II	2·56	85·5
III	3·59	90·6
IV	3·92	90·8
V	4·21	93·8
VI	4·65	95·3
VII	5·36	96·1
VIII	5·74	92·1
IX	7·39	80·4

The plot of the diamagnetic susceptibility against degree of polymerization (see graph) shows a maximum at the original medium degree of polymerization; the stability of the latter is therefore marked by its magnetic behaviour too. The rise is explicable by the decrease in double links with increasing degree of polymerization, the double links possessing a paramagnetic increment (Pascal). At higher degrees of polymerization, a paramagnetic component seems to become of increasing importance.



Diamagnetic susceptibilities of polyindene fractions

Further experiments will show whether the effect is of general significance or not.

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Globule Size in Two-Phase Emulsions

A THEORY that in an oil hydrosol the globules tend to reach a stable size, at which there is a balance between electrical and capillary forces, was advanced by Lewis[1] and extended by Knapp[2] for solid particles. For a particle surrounded by an electrical double layer, Knapp derived the equation

$$r_c = + \left(\frac{e^2\delta}{8\pi\varepsilon\gamma}\right)^{1/4}, \qquad (1)$$

where r_c is the 'critical' radius at which the solubility of the particle is equal to that of a plane surface of the same material, e is the electric charge on the particle, δ the thickness of the double layer (assumed to be small compared with r_c), ε the dielectric constant of the medium and γ the interfacial tension between particle and medium.

Lewis[3] considered in some detail the process of growth of an oil globule by the accretion of *uncharged* oil molecules to a charged ultramicron. He deduced that, in consequence of equation (1), the ultimate charge density should be independent of the globule radius, and argued that the size eventually reached by an ultramicron should be determined by its initial charge, which was assumed to remain constant during growth.

I have recently re-examined the calculations of Lewis and Knapp, and have reached the conclusion that no balance between electrical and capillary forces is possible at a particle surface where there exists an electrical double layer in equilibrium with the environment. Knapp, like Lewis, assumed that the charge on a particle remains constant during changes of radius, and in effect this means that he compared the solubility of a *charged* particle with that of an *uncharged* plane surface. For equilibrium in an ionic environment, however, both surfaces must have the same charge density, and the total free energy of a particle surface (capillary + electrical) will be proportional to the surface area. It will not reach a minimum value for a critical radius of particle as deduced by Knapp, and equation (1) no longer follows.

In considering the growth of an oil globule in a supersaturated solution, Lewis ignored the decrease in free energy of the environment on transference of an (uncharged) oil molecule to the globule. His argument implies that the free-energy change is confined to the globule surface, and hence that the surface free energy required for enlargement of the globule must be provided by the electric charge. As a generalization this is certainly incorrect, and it is unnecessary to invoke the electric charge at all for a highly supersaturated system. The conditions under which energy of supersaturation enables liquid globules to originate and grow in such a system have been discussed elsewhere[4], in connexion with emulsions formed by distilling oil vapour into an aqueous solution, and need not be elaborated here.

A more extended discussion of the Lewis Knapp theory will be published elsewhere. I am indebted to Mr. N. Wookey for valuable assistance in the mathematical examination of the papers cited.

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An Exchange Reaction Involving Alkyl Oxygen and Sulphur

Incidental to the preparation of some sulphur analogues of the synthetic female sex hormones[1], we have been studying the relative stability of anisole and thioanisole to various acidic and basic reagents.

In one experiment we heated anisole (1 mole), thiophenol (1 mole) and an alcoholic solution of potash (1·5 mole) at 200° for six hours and obtained a quantitative yield of thioanisole and phenol.

This result is surprising for at least two reasons: first, because the demethylation of anisole in the absence of thiophenol, under the same conditions, was of the order of 5 per cent; and secondly, the reaction was carried out in the presence of ethyl alcohol, and apparently no thiophenetole was formed. (Later, the migration was found to occur equally well in aqueous medium.)

The reaction also has its interest because it may be used in demethylating other ethers, such as hexœstrol and stilbœstrol dimethyl ethers at a lower temperature in a shorter time than previously reported. For example, hexœstrol dimethyl ether was quantitatively demethylated in four hours at 200° C., whereas Dodds, Golberg, Lawson and Robinson[2] advised sixteen hours at 228° C.

This work will be published in more detail elsewhere.

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Metabolic Studies with 3-Methylglucose

Since the chemical and physical properties of 3-methylglucose closely resemble those of glucose, it was of interest to determine how the introduction of a methoxyl group into the glucose molecule affected its metabolism in the body.

50 per cent aqueous 3-methylglucose was fed to starving rats by stomach tube, and estimation of the liver glycogen and carcass glycogen-level carried out and compared with that of similar rats fed glucose or water. It was found that the liver and carcass glycogen-level of the 3-methylglucose-fed rats was not significantly greater than that of the water-fed rats. In addition, the methoxyl content of the acid hydrolysates of the glycogens of the 3-methylglucose-fed rats was no greater than that of the water-fed rats. It is concluded from these experiments that 3-methylglucose is not glycogenic in the rat and does not give rise to a methylated glycogen.

It was possible to account for an average of 92 per cent of the administered sugar in the urine of rats which had received an intraperitoneal injection of a 6 per cent solution of 3-methylglucose. That the sugar present in the urine was 3-methylglucose was shown by preparing the osazone, which has a crystalline form differing from that of a similar derivative of glucose.

By estimating the loss of reducing power of a glucose solution during fermentation with bakers' yeast in the presence and absence of 3-methylglucose, it has been shown that the latter does not affect the rate of fermentation of glucose by yeast. It has also been shown that 3-methylglucose does not competitively inhibit the synthesis of a polysaccharide from glucose-1-phosphate with a crystalline muscle phosphorylase preparation as does glucose[1].

In spite of the apparent non-utilization of 3-methylglucose in the rat, it is absorbed from the small intestine of the rat at a rate only 16 per cent lower than that of glucose[2].

It is hoped to publish these results more fully elsewhere.

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Micellar Organisation in Primary Cell Walls

In recent X-ray investigations[1] upon the cell wall organisation of conifer cambium, it was observed that much of the diffuse radiation tending to mask the diffraction diagram of the cellulose could be eliminated by a preliminary extraction of the tissue with pectic solvents or with dilute acid (0·1 *N* hydrochloric acid).

In more recent work, using pellets of cambium from *Pinus sylvestris*, or of the parenchyma of *Avena* coleoptiles, it has been observed that in the untreated specimens the diffraction rings of 3·9 A. spacing were prominent (Fig. 1), while the 5·4 and 6·1 A. diffraction rings were only faintly visible or absent. Upon extraction with the above reagents, however, the

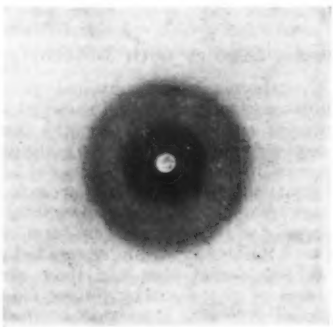

Fig. 1

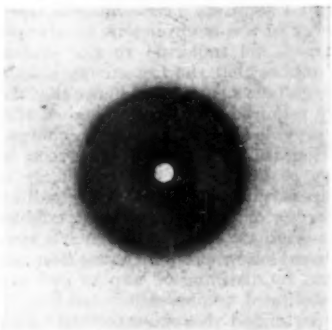

Fig. 2

3·9 A. diffraction ring was considerably sharpened, and additional rings corresponding to spacings of 2·56 A. and 5·5 A. (possibly corresponding to the fused 5·4 and 6·1 A. spacings) became apparent (Fig. 2). From measurements of the 3·9 A. spacing at half maximum intensity, the average micelle breadth was calculated, using the Scherrer formula, to be 18 A. in the unextracted tissue and 26 A. after extraction, as compared with a value of 58 A. obtained for ramie under the same conditions. This apparent change in micelle size, taken in conjunction with the appearance of additional diffraction rings upon extraction, would seem to indicate a considerable increase in the crystallinity of the specimen as a result of the extraction treatment, and it is of interest to consider the manner in which this change could have taken place.

The sharpening of the 3·9 A. diffraction ring, coupled with the increased intensity of rings corresponding to planes both parallel and perpendicular to the micelle length, leads to the conclusion that the micelles had increased in both length and breadth as a result of the extraction treatment. An increase in length can be envisaged as arising from the increased orientation of cellulose molecules at the ends of the micelles, upon the removal of extraneous materials from between them; while an increase in breadth could possibly result from the condensation of molecules oriented parallel to the micelle length, but in the untreated tissue separated from the micelle surface by pectin and other cell-wall constituents. Thus, according to this conception, it is assumed that in the natural state the micelles are surrounded by parallel cellulose molecules separated from one another and from the micellar surface by other cell-wall constituents. Such a view would seem to be consistent with the observed difficulty in obtaining the normal cellulose reactions—for example, with iodine and sulphuric acid—in cambium cell-walls, unless they are subjected to a preliminary acid hydrolysis. Furthermore, if such a view can be considered as extending to secondary cell walls, it may well account for the known difficulty in extracting the last traces of cell-wall constituents such as xylan and lignin[2], which may be considered as held between the cellulose chains immediately adjacent to the micelles, and may account for dichroism of lignin observed in some tissues[3,4].

It may also be noted that the recent work of Hessler, Merola and Berkley[5] has shown in the primary wall of cotton the degree of polymerization of the cellulose is 5,940 compared with 10,650 in the secondary wall, and it may be that this difference is related to the smaller micelle size observed in primary cell walls during the present investigation.

Finally, the extremely small micelle size here observed in primary walls is of interest in relation to the recent electron microscopic investigations of Preston *et al.*[6] on *Valonia* and of Frey-Wyssling[7] on some primary and secondary cell walls. In both these investigations fibrillar strands of cellulose of 250–300 A. in diameter have been observed; but whereas in the case of secondary walls the micelles are 60–70 A. in diameter[8], in primary walls as shown above they are only about 20 A. in diameter. It would thus appear that the fibrillar strands observed in the electron microscope represent super-micellar units, which possess an approximately constant breadth irrespective of the size of the micelles of which they are composed.

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Processa æquimana Paulson in the North Sea

In a recent communication Cattley and Harding[1] reported the presence of an exotic cladoceran, *Penilia avirostris*, off the Dutch coast. We can now report the occurrence of larvæ indistinguishable from the larvæ of the decapod *Processa æquimana* Paulson[2] in the southern North Sea. Although we have not observed any of the adults of *P. æquimana*, the larvæ are so distinctive that there is little doubt that this species is now present and actively reproducing in the North Sea. It has previously been found only in the Red Sea[2], Suez Canal[3] (larva only) and, recently, at Naples[4].

The larvæ have been recognized in our collections from 1946 onwards, and there is reason for believing that the numbers in the North Sea increased each year during 1946–48. They are by no means uncommon. The continuous plankton recorder, alone, collected more than thirty specimens in 1948. In comparison, in our post-war material, the larvæ of *P. edulis* are rare and those of *P. canaliculata* have not been observed in the southern North Sea.

Much of our material has come from the south-west Dogger Bank region, and there are several records south of this. Larvæ have been obtained during July–November with a maximum in August–September.

Ships returning from the Middle East during the War, with empty holds, may well have brought these exotic species to the North Sea in water ballast. Such a transportation is believed to have happened in the past, notably in the cases of *Biddulphia sinensis* and *Eriocheir sinensis*. The former case is particularly appropriate since one of the tropical areas in which it is common is the Red Sea.

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A New Method of Ciliary Feeding in the Brachiopod *Neothyris lenticularis*

The Pygocaulian Brachiopod *Neothyris lenticularis* possesses sets of ciliated filaments similar to those in other invertebrate filter feeders. Studies on this form, however, have shown that the method of feeding is very different from that in other ciliary feeders —Lamellibranchs[1], certain sedentary Gastropods[2], Cryptocephalous Polychætes[3], Tunicates and *Amphioxus*[4], Entoproct and Ectoproct Polyzoa[5,6] and *Crania*[7]. There are two fundamental points of difference, namely, the function of the filaments and the direction of beat of the cilia on the filaments.

In the groups of ciliary-feeding animals referred to above, the rows of filaments, in lying between the ingoing and outgoing currents, function as a 'sieve plate'. In *N. lenticularis* they fulfil the function of lamellæ which serve to delimit an inhalant chamber as a system of channels, surrounded by an exhalant chamber. The inhalant chamber consists of two lateral gutters, formed by the lateral arms of the lophophore, and a single spiral channel of decreasing cross-section, formed by the oral disk and spiral arm. The exhalant chamber is that part of the mantle cavity not occupied by the lophophore, and opens anteriorly at the median anterior region of the gape.

The differentiation of the cilia on the filaments of *N. lenticularis* into lateral and frontal rows is similar in form to that of molluscs, ascidians, etc. In these forms the lateral cilia beat at right angles to the filaments, thus creating the main current. The frontal cilia beat towards the food grooves, carrying particles abstracted from the current. In *N. lenticularis* both sets of cilia beat in the same direction, that is, towards the distal tips of the filaments and away from the food grooves. The function of the lateral and frontal cilia is primarily that of cleansing. The lateral cilia, by their close apposition, serve to reduce to a minimum the inter-filamentar spaces. In this way also the lamellar nature of the rows of filaments is increased.

As a result of these basic points of divergence, certain features in the functioning of the feeding mechanism of *N. lenticularis* are noted, and a theory is given of the mode of selection of food particles.

(1) The lateral cilia cannot create a current, therefore a current is initiated in the region of maximum ciliary beat in one direction. This 'weighting' of ciliary beat occurs in the median region of the mantle cavity, where the action of the cilia lining the mantles combines with that of the cilia lining the spiral arm in directing a current of water through the anterior opening of the shell.

(2) The course of this current is a necessary result of the form and disposition of the lophophore within the mantle cavity. To replace the volume of water which is being discharged in the exhalant current, a constant supply of water is drawn in by way of the lateral inhalant openings, despite the fact that the cilia lining the inhalant chamber beat towards the tips of the filaments. The inhalant currents pass between the dorsal and ventral filaments, travel in a posterior direction following the brachial membrane of the lateral arms and converge in the region of the mouth. The current then flows into the blind channel forming the spiral. To maintain any velocity in a blind channel of decreasing cross-section, water must be exuded along its length. Thus, water is pushed out between the tips of the filaments along the length of the channel into the exhalant chamber. In other words, there is a continual leakage from the inhalant chamber into the exhalant chamber as the current flows round the spiral channel.

(3) Within the spiral arm, as a result of its form and relationship to other structures, a centrifugal force operates which leads to the sorting and collecting of food particles. As soon as the ingoing current has passed through the comparatively narrow inhalant opening, its speed is reduced and heavier particles in suspension drop on to the filaments and are passed to the mantle edge by the lateral and frontal cilia. Lighter particles remain in suspension in the current as it flows in a posterior direction along the brachial membrane of the lateral arms, and following this membrane, turns medially into the oral disk, from which it flows in an anterior direction into the spiral channel. If a change of direction is imposed upon a fluid travelling at any velocity, a centrifugal force will come into operation. Thus there is a tendency

for particles, hitherto in suspension in the water, to fly at right angles from the base (the brachial membrane) towards the apex (the interlocking tips of the filaments) of the channel forming the spiral. Further, with the reduction in cross-section of the channel there is an increase in this tendency due to the ever-decreasing radius of the spiral curve. As a result of the operation of a centrifugal force, the heavier particles are forced towards the apex, while the lighter particles remain near the base of the channel. The heavier particles, forced towards the apex, are caught by the lateral and frontal cilia on the filaments and are forced between the tips of the filaments into the exhalant chamber. In remaining near the brachial membrane, the lighter particles will accumulate in an area which lies between the brachial lips. If particles are placed in this area, it has been observed that the action of the cilia on the brachial lips draws them into the groove. Particles, on entering the brachial groove, are rapidly transported by the cilia at its base towards the mouth.

In *N. lenticularis* the production and course of the current and the processes of food collecting and sorting are the resultant of the action of all the cilia in conjunction with the particular disposition of the lophophore within the mantle cavity.

A full account of these researches will be published elsewhere.

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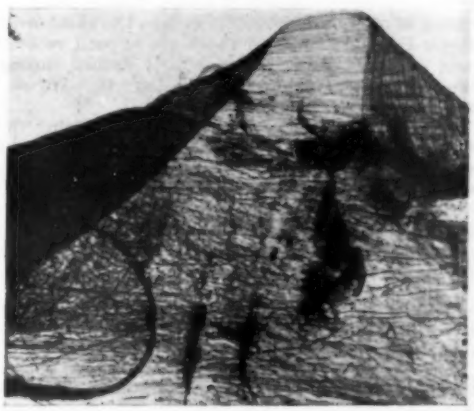
Nature of the Ground Substance in Interstitial Connective Tissue

DAY[1,2,3] has recently concluded that the cementing substance (the so-called amorphous ground substance) of the interstitial connective tissue is protein and not mucoid. We have now obtained some evidence in support of this conclusion by histological examination of this tissue from the deep fascia of the rat. Squares of tissue were attached at the four corners to micro-slides by means of collodion[3]. Some of the slides were immersed for several days in physiologically isotonic saline, some in 60 per cent ethyl alcohol and some in a saturated mercuric chloride solution. In order to try to ensure that a negative staining result would not be obtained merely because any mucoid present had been dissolved out, some of the slides, after the alcohol and saline treatments, were fixed in 10 per cent formalin for ten minutes, some by exposure to formalin vapour[4], and some were stained without further fixation. The tissue was then stained by toluidine blue[5], by McManus's method of periodic acid followed by Schiff's reagent[6,7] or by Hale's method of dialysed iron followed by potassium ferrocyanide[8]. Some of the alcohol preparations were also impregnated with silver by Foot's method[9].

No satisfactory evidence of mucoids in the ground substance was obtained. In toluidine blue preparations, the majority of the cells stained a pinkish-blue and the larger mast cells were vividly pink with numerous metachromatic granules. Fibres and ground substance did not stain. By McManus's method all the fibres and cells stained pink, but there was no general pink staining of the ground substance. With Hale's method the fibres and cells stained blue. Both McManus's and Hale's methods are, however, open to the criticism that if the preliminary periodic acid, or iron, is not completely removed, the colour will develop even if no mucoid is present. The false staining reaction with McManus's method was demonstrated by the use of potassium periodate instead of periodic acid[10], when the tissue stained in the same way as when periodic acid was used. Again, with Hale's method the collodion affixing the tissue to the slides became bright blue, in spite of repeated attempts to wash out the dialysed iron.

By each of the three methods, the very fine reticular fibrils precipitated from the ground substance by the alcohol or the mercuric chloride[3] stained as the larger collagen fibres.



The lamellar structure of the interstitial connective tissue of the rat, fixed in alcohol and impregnated with silver. (× 55)

These preparations again demonstrated clearly the arrangement of the fibres of the tissue in laminæ. The accompanying photograph, for example (silver impregnated), shows that when the tissue curled over on the slide the fibres did so as in a layer, and did not move independently of each other.

We wish to thank the Council of the British Leather Manufacturers' Research Association for permission to publish this note, and also Dr. T. D. Day for preparing the tissue.

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A Mutant Genoid in *Drosophila* Sensitive to Carbon Dioxide

SENSITIVITY to carbon dioxide in *Drosophila melanogaster* is believed to depend on the presence in the cytoplasm of an agent which has been called a 'genoid'. As established by L'Héritier and Teissier[1], males of the standard sensitive stock transmit genoids, therefore sensitivity, to a variable but important fraction of their progeny. Sensitive females transmit it to all their offspring.

This rule is usually observed in stocks which are made sensitive by injection of hæmolymph from sensitive flies of the standard stock, or by grafting ovaries from resistant larvæ into sensitive ones[2]. However, a stock carrying the sex-linked gene *white*, made sensitive by injection of hæmolymph from sensitive flies, was found to have a different pattern of inheritance of sensitivity. Progeny of females of this stock were always sensitive, while progeny of sensitive males were rarely so. Experiments were undertaken to see whether this pattern of transmission of the genoid was due to an influence of the genotype of the w stock upon the genoid, or to a mutation of the genoid, rendering it unable to infect the male germ.

Females from the standard sensitive stock (called $\sigma - e$)—the stock previously called *ebsBs* which contains the gene *ebony*—were crossed with males from the w sensitive stock (called $\sigma - w$) and, reciprocally, $\sigma - w$ females were crossed with $\sigma - e$ males. $F1$-sensitive females of the two lines were back-crossed to wild-type resistant males, and the back-crosses repeated during nine generations. In each generation, the capacity of males to transmit sensitivity (that is, their 'valence') was determined. It was found that, in the line started with $\sigma - e$ females, the males maintained a high valence (between $54{\cdot}5 \pm 0{\cdot}4$ and $80{\cdot}5 \pm 0{\cdot}4$) during the nine generations, while in the line started with $\sigma - w$ females, the valence remained very low (between $0{\cdot}11 \pm 0{\cdot}05$ and $8{\cdot}0 \pm 0{\cdot}3$). This result rules out the possibility of an immediate influence of the genotype of the *white* stock upon the genoid.

As it has been shown elsewhere[3], exposure of sensitive flies to high temperature (30° C.) can, in certain conditions, 'cure' their germ cells. It is thus possible to obtain a genoid-free stock from any sensitive stock. Using the transplantation technique of Ephrussi and Beadle[4], larval ovaries free of genoid, from 'cured' $\sigma - e$ stock, were implanted into sensitive larvæ of the $\sigma - w$ stock and, reciprocally, ovaries from cured larvæ of the $\sigma - w$ stock implanted into sensitive larvæ of the $\sigma - e$ stock. Likewise, larval ovaries from a wild-type resistant stock were grafted into the two types of sensitive hosts, $\sigma - e$ and $\sigma - w$.

The valences of males descended from each type of grafted ovaries were determined. A very striking fact appeared: males whose genoid comes from the $\sigma - e$ host had, whatever their genotype, a high valence ($21{\cdot}4 \pm 2{\cdot}7$ and $29{\cdot}0 \pm 6{\cdot}8$), whereas males whose genoid comes from the $\sigma - w$ host had always a very low valence ($0{\cdot}66 \pm 0{\cdot}05$ and $3{\cdot}5 \pm 3{\cdot}4$). Since this situation persisted in the following generations, it was possible to establish two strains of $\sigma - e$, one with high-valence males and another with low-valence males; and similarly two strains of $\sigma - w$, with the same characteristics.

The fact that two types of males may be obtained in any stock was verified by building up several similar pairs of sensitive stocks, from strains carrying the genes *sepia*, *eyeless* and *yellow*. In each pair, one stock has high-valence males, the other low-valence males; and this difference was found to persist through many generations.

These facts are best interpreted by the assumption that the genoids present in the $\sigma - w$ stock have undergone a mutation limiting strongly their capacity to infect the male germ.

A full account of these experiments and a discussion of a possible mechanism of a fortuitous selection of mutant genoids will be published in the *Bulletin Biologique France Belgique*.

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Paris.

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Mechanism of Nitrogen Assimilation from Amino-Acids by Yeast

EHRLICH[1] showed, in general, that an α-amino-acid if supplied to yeast as its sole source of nitrogen undergoes deamination, since the corresponding higher alcohol can be recovered from the fermented medium; he inferred that the ammonia simultaneously liberated is utilized for the synthesis of cell proteins. Coupled with the known fact that fusel oil (a mixture of these higher alcohols) is produced during the fermentation by yeast of natural substrates such as beer wort, the primary source of nitrogen of which consists of a complex mixture of α-amino-acids, this work of Ehrlich initiated the widespread view[2] that deamination of α-amino-acids is the normal mechanism of nitrogen assimilation by yeast. It is a corollary of this view that no amino-acid could be superior to ammonia as a nitrogen nutrient for yeast. While this is generally true when single amino-acids are used as the nitrogen source[3] (deamination being obligatory in such cases), it is demonstrably false when the nitrogen is supplied as a mixture of many amino-acids. I have shown that approximately half the assimilable nitrogen of beer wort is assimilated by yeast fully five times faster than ammonia nitrogen.

An entirely reasonable hypothesis to account for this behaviour is that, when all the amino-acids needed for the production of yeast proteins are present in the medium, they do not undergo preliminary deamination but are integrated intact into the protein structures. Deamination may be presumed to occur only so far as may be necessary to furnish ammonia for the synthesis of amino-acids in short supply or absent from the medium—and for the synthesis of other types of nitrogen compounds required by the cell.

Some deductions from this hypothesis which have been experimentally confirmed are as follow. (1) The superiority of amino-acid mixtures over ammonia increases with increasing complexity of the mixtures. (2) The assimilation of intact amino-acids results in more of the carbohydrate of the nutrient medium being available for fermentation than would otherwise be the case. (3) If, as there was reason for thinking, pyridoxine is involved in the deamination of amino-acids[4], it will be more dispensable with complex amino-acid mixtures, as well as with ammonia, than

is the case with single amino-acids; this has been found to be true. (4) Certain amino-acids which yeast is unable to deaminate, for example, lysine, are nevertheless rapidly assimilated by yeast from complex mixtures[5].

A full account of this work will be published elsewhere.

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University, Birmingham, 15.
March 2.

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Earthworm Chætæ

It is now established[1-3] that the hard cuticle of insects owes its rigidity and to some extent its colour to the tanning of its protein constituents by an orthoquinone. Similar tanning takes place to a less extent in Crustacea[4]. This type of hardening is not, however, confined to the Arthropoda, for Stephenson[5] has shown that in the Trematoda the egg capsules may be similarly hardened, and the following observations on the chætæ of the earthworm *Allolobophora longa*, suggested by their amber colour, indicate that they, too, are hardened by quinone tanning.

Like the insect cuticle, the chætæ consist basically of a chitin–protein complex. As reported by Goodrich[6] for the chætæ of *Lumbricus*, they give positive reactions to the xanthoproteic and Millon tests, and, further, they are strongly positive to the Campbell chitin test. Evidence that the amber coloration of the chætæ is due to tanning by an orthoquinone is given by the fact that, even after boiling, they induce rapid oxidation of a mixture of dimethyl*para*phenylene-diamine and α-naphthol (Nadi reagent) found useful as an indicator of the presence of orthoquinones in insect and crustacean cuticles[2,4]. The amber-coloured distal portion of the chæta becomes deep blue, whereas the pale or colourless portion proximal to the nodulus remains uncoloured. The argentaffine reaction for polyphenols, aminophenols and polyamines is only moderately positive and is uniform over the length of the chæta. As might be expected from the staining reactions of the hard insect cuticle[2], the amber portion of the chæta does not stain with acid fuchsin, whereas the proximal portion stains readily. In view of these indications of quinone tanning, it is not surprising that the chætæ are bleached and softened by diaphanol (chlorine dioxide in glacial acetic acid), and it is evident that they strongly resemble the insect exocuticle in general chemical constitution.

Like the insect exocuticle, the chætæ are covered, possibly as a protection against abrasion, by a resistant surface layer of different composition. As noted by Goodrich[6], chætæ boiled in concentrated potassium hydroxide solution and then treated with cold concentrated hydrochloric acid dissolve at their proximal ends. On boiling the acid the distal end dissolves, but a thin sheath or covering cap remains. This sheath covers precisely that part of the chæta which is extruded in locomotion, and its resistance to solution in hydrochloric acid suggests a resemblance to the thin epicuticle of an insect[2].

It seems probable that quinone tanning of protein structures may be of widespread occurrence in the invertebrates, and it will be of interest to learn whether future observations confirm this view.

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Manchester 13.
March 9.

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A Factor Limiting Downward Spread of some Scottish Mountain Plants

Some species of flowering plants on Scottish mountains are rarely found below 2,000 ft., and one factor which may limit their downward spread is sensitivity to winter rain. These plants have rarely been cultivated in the wetter parts of Britain, which may explain why this factor has received little or no attention, although it is quite familiar with many high alpines from the Himalayas.

The only relevant rainfall figure available is for the top of Ben Nevis, where the mean annual rainfall for a period of years exceeded 160 in., and fell as rain or snow on an average of 263 days a year. Plants growing above 2,500 ft. are subjected to almost daily rain in summer; but between October and May they are under a more or less continuous cover of dry snow, and the mean January temperature on the summit of Ben Nevis for the same period was 21° F. Conditions are, therefore, comparable with high alpine regions in other parts of the world, and in a mild lowland situation with only 40 in. of rain a year some Scottish mountain plants are difficult to keep in cultivation through the winter.

The following species are sensitive to winter wet and are liable to die off: *Veronica fruticans*, *Cerastium alpinum*, *C. arcticum*, *Arenaria rubella*, *Cherleria sedoides*, *Lychnis alpina* and *Gnaphalium supinum*. The latter species may be found on bare screes as low as 1,000 ft.; but at such levels it usually grows as an annual. Higher up, marked plants have been known to survive for five years. If protected from winter rain, the species listed above survive the winter and are quite unaffected by frost.

During the winter of 1946–47, the grass minimum temperature reached 0° F. at Auchincruive, but of more than a hundred plants grown in pots in the open, only *Athyrium flexile* was killed. Except for some littoral species growing in gritty soil (*Mertensia maritima*, *Primula scotica*), none of the arctic-alpines found at sea-level on the north Scottish coast are sensitive to heavy winter rain, nor are some of the high mountain plants. Among others, the following have survived for several years in the open: *Draba rupestris*, *D. incana*, *Saxifraga cernua*, *S. aizoides*, *S. oppositifolia*, *S. stellaris*, *Potentilla Crantzii*, *Veronica alpina*, all mountain species of *Salix*, *Oxytropis uralensis*, *O. campestris* and *Astragalus alpinus*.

H. F. Dovaston

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March 12.

Underground Water Provinces, Districts and Sub-Districts

TOLMAN[1] shows, in his work on underground water, that over a large area there are water provinces; and Bond[2], in South Africa, after a geochemical survey, has grouped the underground waters of South Africa into five main types. In any of these areas local anomalies are found, so that it is necessary to divide the waters into districts (say, areas of 100 square miles or so) and sub-districts and portions of smaller area. It has been found that electrical resistivity measurements are primarily dependent upon the rock formations over which the work is carried out, and as water is a mineral and when in bulk constitutes a rock formation, its chemical nature and hence its resistivity are most important.

I have found in working over diabase–shale–quartzite horizons that the underground water depends upon the formation, and after checking many boreholes can, in many doubtful cases (outcrops being absent and boreholes without records), say whether the borehole is situated in diabase, shale, granite, quartzite or dolomite from a determination of the resistivity of the water. As this is very easily determined, it is a great help where outcrops are absent.

The following data are given to show the order of the values obtained in various areas:

Formation	Resistivity of water at 20–21° C.	Locality
Black Reef quartzites	3500	Zebediela
Karroo basalt	780	"
Diabase (dolerite to syenite)	2000–4000	Western Transvaal
Quartzite	25,000–80,000	" "
Granite	6000–7000	North of Johannesburg
Dolomite	3360	West " "
Amygdaloidal andesite	3200–7800	South " "
Dwyka tillite	1400–1550	Douglas District
Amygdaloidal andesite	1000	" "
Syenite	1800–4300	Rustenburg "
Karroo shales and sandstones (Ecca)	10,000–15,000	East of Johannesburg
Table Mountain sandstone	7730	Artesian: Uitenhage
" "	2270	Artesian: Amanzi Estate
" "	1240	Artesian: Coega Kop
" "	1300	Artesian: Zwartkops
Cretaceous clays and sandstones*	128–160	Port Elizabeth area
Karroo rocks	330–1700	Odendaalsrust, O.F.S.
Artesian borehole in Karroo rocks	126–160	" "

* These cover the Sundays River artesian basin. See also Heiland (ref. 3).

† Port Elizabeth district.

At Zebediela, the basalt covers the Black Reef quartzites, and electrical resistivity traverses at 100-ft. electrode separation showed scarcely any change from quartzite to basalt. This was apparently due to the large quantities of pure water in the quartzite and the small quantities of saline waters in the basalt equalizing the apparent resistivity values.

Enslin[4] has recently shown that different formations can have a lateral effect on the depth probe values. I have confirmed this independently, and, in fact, now use the effect to delimit the sub-outcrop at, say, 100-ft. depth by setting out the traverses so that the sub-outcrop is intersected at a very small angle. Drilling has proved the correctness of this, and in addition I have carried out the same procedure over well-defined outcrops.

After correlating about sixty depth probes over boreholes of which there were fairly accurate records showing the formations intersected and the positions of water struck, I have found that, except in the case of caves in the dolomite or in interbedded shales and quartzites (caves are very common in such sedimentary rhythms), water cannot be detected in the small fissures and porous layers at rock contacts that characterize South African underground water resources. Very often the water occurs at rock contacts, and these can be easily and accurately inferred from inflexions in the depth probes.

As South Africa is a comparatively highly mineralized country, it is interesting to note that electrical resistivity work has not been successful in locating copper ores[5] or lead ores[6]. Recently, I carried out researches over tin ores which have highly mineralized lodes (tourmaline, hæmatite present in abundance) and found that the lodes could not be detected. This is indeed fortunate, as water is South Africa's most important mineral to-day and in few, if any, circumstances can the resistivity work be affected by mineral deposits, except perhaps manganese and iron.

I am indebted to members of my staff for assistance in the field, and in particular to Messrs. H. G. Trevelyan and J. D. Moore.

V. L. BOSAZZA

Petrologgia, 39 Barkly Road, Parktown, Johannesburg. March 2.

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Relation of the Alpha Rhythm of the Brain to Psychomotor Phenomena

SIMULTANEOUS recordings were made of the alpha rhythm and eye opening in response to an auditory stimulus, using a standard electroencephalograph apparatus. By plotting the number of responses against the phase of the alpha rhythm, a curve was obtained which showed a variation of more than 2 to 1 in the number of responses in different parts of the cycle. The exact distribution of the responses was examined by means of an electronic timing device, which registered a point in the alpha cycle by a signal of short duration, and the eye opening by a similar signal. The time interval between the signals was then measured by recording the charge gained by a condenser. The measurements confirmed that the probability of a response was not randomly distributed in time, but showed peaks and troughs recurring at approximately 10 per second and in accurate phase relations with the alpha rhythm. Similar results were obtained for other voluntary movements.

The observations indicate that voluntary muscular movements are influenced by the electrical rhythms of the brain. The probability of the occurrence of a motor discharge depends on the phase of the alpha rhythm and in certain subjects is greater during a phase of positive potential than during a negative potential on the occipital cortex.

G. O. KIBBLER
J. L. BOREHAM
D. RICHTER

Neuropsychiatric Research Centre, Whitchurch Hospital, Cardiff. March 28.

FORTHCOMING EVENT

Tuesday, August 30—Friday, September 2

INSTITUTION OF NAVAL ARCHITECTS (joint meeting with the INSTITUTION OF DANISH CIVIL ENGINEERS and the FEDERATION OF DANISH SHIPBUILDERS), at Copenhagen.—Autumn Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIFIC OFFICER for research on the nutrition of watercress, and a SECRETARY—The Director, National Vegetable Research Station, c/o Ministry of Agriculture and Fisheries, 1–4 Cambridge Terrace, London, N.W.1 (September 3).

LECTURER (Grade III) IN CHEMISTRY—The Registrar, Queen Mary College, Mile End Road, London, E.1 (September 3).

LABORATORY TECHNICIAN IN THE CLINICAL PATHOLOGY DEPARTMENT of Bridgend General Hospital—The Secretary, Mid Glamorgan Hospital Management Committee, 8 Wind Street, Neath (September 3).

LECTURER IN MATHEMATICS—The Registrar, Loughborough College, Loughborough, Leics (September 3).

ADVISORY OFFICER IN THE DEPARTMENT OF BACTERIOLOGY—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (September 3).

ASSISTANT IN ENTOMOLOGY with particular reference to Forestry—The Secretary, The University, Old College, South Bridge, Edinburgh (September 3).

RESEARCH ASSISTANT (Grade IVa, temporary) IN THE CHEMISTRY DEPARTMENT—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (September 3).

LECTURER IN ORGANIC CHEMISTRY, and a LECTURER IN MATHEMATICS, at the Coventry Technical College—The Director of Education, Education Offices, Coventry (September 3).

SCIENTIFIC OFFICER (with honours degree in Botany or Agricultural Botany) IN THE FIELD BOTANY DIVISION of the Ministry of Agriculture for Northern Ireland—The Secretary, Civil Service Commission, Stormont, Belfast (September 5).

LECTURER IN APPLIED PHYSIOLOGY—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1 (September 10).

ASSISTANT LECTURER IN PHYSICS—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (September 10).

SUPERINTENDENT OF THE HAROLD COHEN LIBRARY—The Registrar, The University, Liverpool (September 19).

INDUSTRIAL CHEMIST at a Ministry of Supply factory in South-East London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.579/49A (September 20).

SENIOR SCIENTIFIC OFFICERS (2) at the Royal Air Force Institute of Aviation Medicine, South Farnborough, under the Air Ministry—(1) a BIOCHEMIST who will be responsible for the investigation of dietetic and other factors which influence the efficiency of flying personnel, (2) a BIOPHYSICIST with research experience in general physics and some experience in the application of physics to physiological problems—The Secretary, Civil Service Commission, 27 Grosvenor Square, London, W.1, quoting No. 2741 (September 21).

CHEMISTS for work in London including liaison duties with the Ministry of Supply and other Government Departments in connexion with application of industrial developments to Service problems—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.580/49A (September 30).

SCIENTIFIC OFFICER (with 1st or 2nd class honours in Chemistry or Botany with subsidiary Chemistry) FOR STUDIES IN PLANT PHYSIOLOGY, and a SCIENTIFIC OFFICER (with 1st or 2nd class honours in Chemistry or Physics) FOR RADIOACTIVE STUDIES—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (September 30).

TECHNICIAN IN THE DEPARTMENT OF ZOOLOGY, Auckland University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

ENTOMOLOGIST to undertake instruction of students reading for Honour School of Forestry, in Entomology and Forest Zoology—The Professor of Forestry, The University, Oxford (September 30).

CHAIR OF PSYCHOLOGY at University College—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 7).

PROFESSOR OF ELECTRICAL ENGINEERING, and a PROFESSOR OF ECONOMICS, at the University of Brisbane—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 15).

DIRECTOR, and an ASSISTANT DIRECTOR, OF THE COMMONWEALTH BUREAU OF DAIRY SCIENCE, Shinfield, Reading—The Secretary, Commonwealth Agricultural Bureaux, 2 Queen Anne's Gate Buildings, London, S.W.1 (October 15).

SENIOR CHEMIST TO THE RUBBER RESEARCH SCHEME (Ceylon)—The Chairman, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, South Kensington, London, S.W.7 (October 31).

LECTURER IN PHYSICS—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

EXPERIMENTAL and ASSISTANT EXPERIMENTAL OFFICERS IN THE DIVISION OF ATOMIC ENERGY (Production) at Springfields Factory, Salwick, Preston, to carry out experimental work arising from the metallurgical development involved in the production of atomic energy—The Staff Section, Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington.

ABSTRACTORS FOR THE LIBRARY AND INFORMATION BUREAU to deal with technical and scientific literature relating to textiles—The Director, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

CROP RECORDER—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

TECHNICIAN FOR PHYSICIST'S DEPARTMENT—The Administrative Officer, Royal Berkshire Hospital, Reading.

LABORATORY TECHNICIAN—The Principal, Dover Technical College, Ladyweil, Dover.

DIRECTOR OF RESEARCH—The Secretary, Wool Industries Research Association, Torridon, Headingley, Leeds 6.

ENTOMOLOGIST in the Sudan Veterinary Service, to carry out a survey of the tsetse areas of the Sudan and undertake research work—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Veterinary Entomologist'.

CONTROLLER OF PATENTS AND DESIGNS in the Industries Division—The High Commissioner for Pakistan, 35 Lowndes Square, London, S.W.1.

GRADUATE (Physics, Mathematics, Chemistry) for combustion and heating problems—The Assistant Secretary, British Coal Utilisation Research Association, Randalls Road, Leatherhead, Surrey.

DEPUTY ACADEMIC REGISTRAR—The Secretary to the Senate, University of London, Senate House, London, W.C.1.

ASSISTANT ENGINEERS (Radio) IN THE POSTS AND TELEGRAPHS DEPARTMENT, East Africa—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27326/27.

CIVIL ENGINEER for investigation in connexion with water supplies, Sierra Leone—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/139.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

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